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NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY. APPENDIX F. UPST--ETC(U)
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North Atlantic Regional Water Resources Study

Appendix F.
Upstream Flood Prevention and Water Management.

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NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY COORDINATING COMMITTEE

(11) MAY 1972

The North Atlantic Regional Water Resources (NAR) Study examined a wide variety of water and related land resources, needs and devices in formulating a broad, coordinated program to guide future resource development and management in the North Atlantic Region. The Study was authorized by the 1965 Water Resources Planning Act (PL 89-80) and the 1965 Flood Control Act (PL 89-298), and carried out under guidelines set by the Water Resources Council.

The recommended program and alternatives developed for the North Atlantic Region were prepared under the direction of the NAR Study Coordinating Committee, a partnership of resource planners representing some 25 Federal, regional and State agencies. The NAR Study Report presents this program and the alternatives as a framework for future action based on a planning period running through 2020, with bench mark planning years of 1980 and 2000.

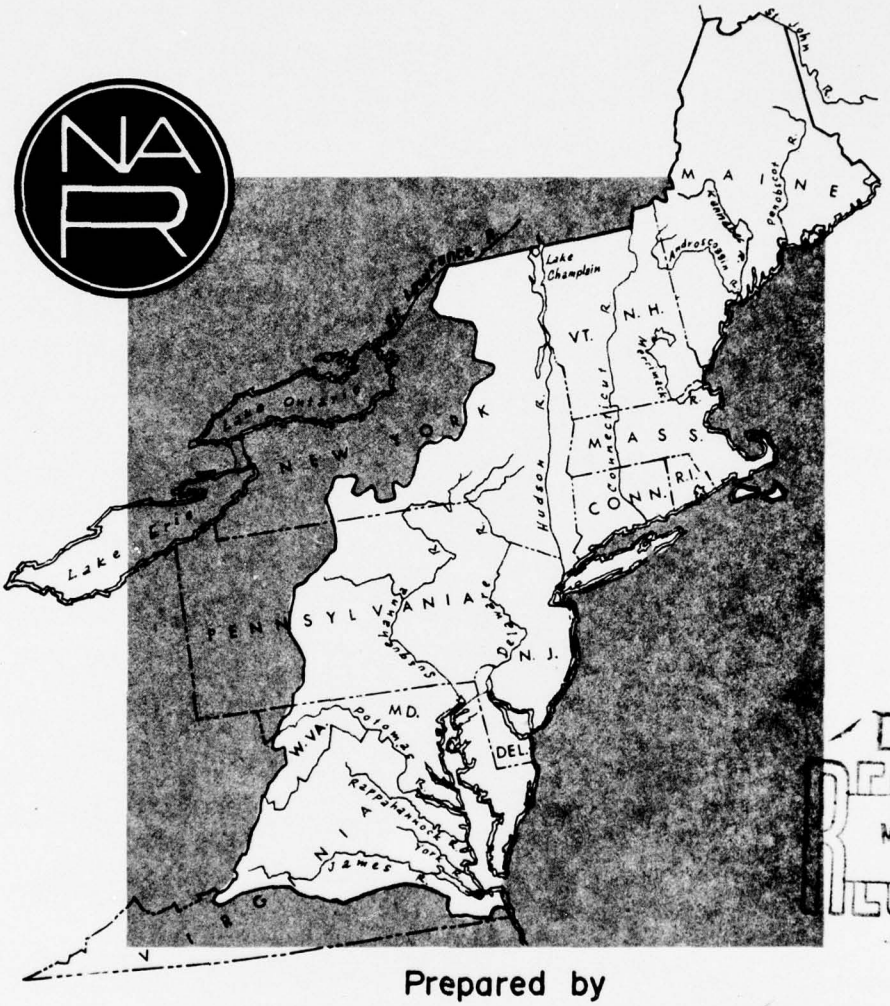
The planning partners focused on three major objectives -- National Income, Regional Development and Environmental Quality -- in developing and documenting the information which decision-makers will need for managing water and related land resources in the interest of the people of the North Atlantic Region.

In addition to the NAR Study Main Report and Annexes, there are the following 22 Appendices:

A. History of Study
B. Economic Base
C. Climate, Meteorology and Hydrology
D. Geology and Ground Water
E. Flood Damage Reduction and Water Management for Major Rivers and Coastal Areas
F. Upstream Flood Prevention and Water Management
G. Land Use and Management
H. Minerals
I. Irrigation
J. Land Drainage
K. Navigation
L. Water Quality and Pollution
M. Outdoor Recreation
N. Visual and Cultural Environment
O. Fish and Wildlife
P. Power
Q. Erosion and Sedimentation
R. Water Supply
S. Legal and Institutional Environment
T. Plan Formulation
U. Coastal and Estuarine Areas
V. Health Aspects

WATER RESOURCES NEEDS AND POTENTIALS FOR AN EXPANDING SOCIETY

Appendix F
Upstream Flood Prevention and Water Management



Prepared by

North Atlantic Regional Water Resources Study Group
North Atlantic Division
Corps of Engineers, U.S. Army

for the

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY
COORDINATING COMMITTEE

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I - SYLLABUS

Average annual flood damage in upstream areas in the North Atlantic Region (NAR) has increased over the years and is presently about $55 million. If no measures are undertaken to prevent flood damages, the annual damage will increase to $82 million in 1980, $145 million in 2000, and $277 million in 2020.

There have been 109 watershed projects authorized for construction, primarily for flood prevention, as of 1967. These projects include 492 floodwater retarding structures which store 527,000 acre feet of floodwater and sediment and 171,000 acre feet of water for other uses. They also include 1,474 miles of channel improvement. In addition to land already adequately treated, land treatment has been planned on 2.4 million acres. The structural and land treatment measures provide protection to damageable property on approximately 426,000 flood plain acres. The damage reduction benefits attributed to these projects amount to $9 million annually.

Although some flood plains are managed for particular purposes, there are few complete and comprehensive flood plain management plains in the 1,314 upstream watersheds. Plans for managing the 6.1 million acres of flood plain are needed to protect or provide amenities in the form of habitat, recreational, cultural, and scenic areas, maintain or improve quantity and quality water supplies and prevent losses from flood damage. Flood plain management plans need to consider a multiplicity of non-structural and structural measures in combination.

Flood warning systems and proofing and regulation of improvements are some of the non-structural measures to reduce damages on .2 million acres of built-up flood plain. Eliminating new construction would prevent $125 million annual damage by 2020. Establishment of green and blue belts should be considered on 1.3 million acres of flood plain subject to high damages and/or on 4.3 million acres expected to flood within each 10-year period.

There are 353 potentially feasible flood prevention projects in upstream areas. These projects include needed land treatment and management on 11.6 million acres, 1,279 floodwater retarding structures, and 4,237 miles of channel improvements. They would reduce the average annual floodwater damage by about 37 percent. A suggested extent and timing of development of these potential watersheds is that 27 percent, or 96 projects, be implemented by 1980; another 47 percent or 166 projects by 2000; and the remaining 26 percent, or 91, by 2020. The 2.2 million acre feet of floodwater retention and sediment-storage would cost $403 million in multipurpose structures. An additional 4.1 million acre feet storage for other uses could be developed in these projects.

There are 852 upstream watersheds classed as "Potential Developments" in which 2,200 reservoir sites exist. There are projects where there appears to be little justification for flood prevention under an early action program. These sites contain total floodwater detention storage of 4 million acre feet and offer an additional storage potential of 10 million acre feet for other uses.

The physical potential 4.1 and 10.4 million acre feet storage for uses other than floodwater retention and sediment, could be developed for an estimated $2,356 million. The 14.5 million acre feet beneficial use storages have possibilities for satisfying water needs of the region. These needs include recreation, fish and wildlife, irrigation, rural domestic and livestock, municipal and industrial water supply, and water quality control. Water needs appear in functional appendices. Amounts of beneficial storage required in upstream reservoirs to meet these needs will be determined during plan formulation and appear in the Main Report.

Most of the subregions have high potential for watershed development. Preliminary studies indicate that structural measures in potentially feasible flood prevention projects could alleviate upstream flood damages by 61 percent in Subregion A, 31 percent in Subregion B, 13 percent in Subregion C, 49 percent in Subregion D, 50 percent in Subregion E, and 35 percent in Subregion F.

Even with potential flood prevention structural measures installed there will be considerable remaining damages. Flood plain management needs to be evaluated as an alternative and/or complementary consideration to structural measures. In some instances, it appears to be the only recourse for reducing these remaining damages.

More detailed studies are needed to develop flood prevention aspects of water resource plans. Flood prevention plans incorporating structural measures, watershed protection, and flood plain management are needed in Areas 7, 9, 10, 12, 15 and 18 to prevent huge flood damages. Comprehensive plans initiated in Areas 6, 14 and 20 to solve water supply problems should include flood prevention measures. Upstream watershed investigations are needed to ascertain practicability and local interest of potentially feasible projects in areas not selected for detailed river basin studies. These investigations need to include multipurpose uses in both structural and nonstructural flood prevention measures.

II - INTRODUCTION

This is one of 22 subject appendices to the Main Report of the North Atlantic Regional Water Resources Study (Type I). The coordinated comprehensive Study provides a framework into which can be fitted projects and programs designed to best serve water and related land resource needs of people in the region.

PURPOSE AND SCOPE

Purpose

The purpose of this appendix is to develop and document the investigation and analysis of (1) flood prevention aspects in upstream watersheds, and (2) upstream storage potentials and cost of the storage. The findings serve as input to plan formulation and the main report.

Scope

The study was limited to the application of existing data, ongoing studies, and a broad inventory analysis in upstream watersheds. "Upstream" refers to those streams above a point where the total area drained is less than 250,000 acres (390 square miles). Main stems and major tributaries of more than 250,000 acres drainage area are covered in Appendix E, Flood Control and Water Management on Main Stems and Major Tributaries.

Flood damages were compiled, updated, and projected for the target years 1980, 2000 and 2020. Feasibility, benefits and costs associated with flood prevention were developed. The extent and timing of structural flood prevention measures were estimated for the time frame years 1980, 2000 and 2020. The significance of flood plain management measures was discussed. Water supply storages and costs were determined.

All studies were broad in nature and avoided local detail. The information is presented with the degree of refinement in accord with developed guidelines for comprehensive framework Type I studies.

HISTORY

The NAR has a long history of too much water when it is not wanted or too little when it is wanted. The experience of the last decade proved no exception. Floods have claimed several hundred lives and millions of dollars damage. During the same decade, there were periods in many areas where the demand for water greatly exceeded the supply.

Floods

A flood may be defined as the occurrence of a flow of such magnitude that it overtops the natural or artificial banks in a reach of river channel. This water then flows over the flood plain resulting in damages and possible loss of life.

Hoyt and Langbein[1] in a study of frequency of overbank flow at 140 locations in the United States found that it is remarkably consistent among rivers. They found that on the average overbank flow of natural channels could be expected to occur every two years.

The question naturally arises as to why the channel built by the river is not generally large enough to carry the unusually high flows. This is due mainly to a series of complicated actions and reactions of water and sediment leading to a type of equilibrium between river water and river channel which requires the existence of a flood plain. A flood plain can then be defined as a relatively flat area bordering a stream and built of sediments deposited by the stream.

Types and Causes. The usual cause of floods is excessive runoff. Floods have been due to intensive rainfall, rapid snowmelt, high tide, and overtopping or failure of reservoir dams with sudden release of large volumes of water.

Storms in the region are of two general types, namely storms of tropical origin (hurricane) and storms of extra tropical origin such as thunderstorms and northeasters. Tropical storms, a result of interactions between differing air masses in the temperate zone, produce intense rainfall. Extratropical storms, a result of convection instability often occurring within an air mass, pose the greatest threat to small watersheds.

Magnitudes and Losses. Word descriptions of outstanding floods in the NAR date back to 1635.[2] There is only one reference found concerning floods prior to the coming of the English to New England in 1620 and this was considered to be legendary. Systematic records of river discharge for the most part date back only 65 years. From the descriptions, "It is fairly certain that the recent floods exceeded all historical floods back to the date of white settlement some 200 to 300 years ago".[2] This is significant in that it indicates that the highest recorded flood in the NAR covering only 65 years or so is also the highest in 200 to 300 years.

From 1902 to 1967 losses in individual severe floods in the NAR occurred in 1924, 1927, 1935, 1936, 1938, 1942, 1945, 1947, 1948, 1949, 1953 and 1955. The property damage ranged from $2 million to in excess of $760 million. There was a loss of life of more than 200 persons in the 1955 flood event. For the period 1925 to 1967 total NAR property damage average in excess of $26 million annually

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(1) Numerals in parentheses refer to the bibliography at the end of the Appendix.

with a loss of life of about 11 persons annually. For this same period of time the United States average property damage was $203 million annually with a loss of life of 78(3) persons annually. The region compared with the country as a whole contains only 5 percent of the nation's land area bu has incurred about 13 percent of the flood losses.

Localized floods in small watersheds have occurred throughout the region every year. These floodwaters have caused an estimated damage of $9 million annually for the period 1925 to 1967. Damage to crop and pasture accounts for about one-third of the total damage. Damage to other agricultural property such as farmsteads, fences, livestock, and farm lanes has amounted to nearly $1 million. Much of the $5 million annual damage to nonagricultural property occurred in rural communities and small towns; about 32 percent was to residences, 34 percent to commercial and industrial, 22 percent to transportation facilities, and 12 percent to other properties.

Over the years there has been increased movement into the flood plains by agriculture, private dwellings, industry, and other developments. This movement with its increased damageable values has been largely responsible for the increase in flood damages, rather than an increase in peak discharges or frequencies. Most of the average annual damage occurs from 10 year frequency floods and less. Floods up to a 10 year frequency cause about 75 percent of average annual damage to agricultural lands.

Water Management

"The habits of men and the forms of their social organizations have been influenced more by their close association with water than with the land by which they earned their bread."(4) Farmers have had to haul water for livestock in trucks from cities. City Councils have been warned that the growth of their cities would be limited by the availability of water. Water in the reservoirs that serve New Yorkers has been so low they were asked to cut down on the use of water. Homeowners in many areas were asked to give up watering their lawns in order to conserve municipal supplies. The proper development and utilization of the water resources is imperative to the future growth of the region.

Private groups and municipal, county, state, and federal governments have participated in water management practices. The Department of Agriculture (USDA) under its Public Law 566 (PL 566), Public Law 534 (PL 534), and Conservation Operations (CO) programs has installed structures for flood prevention, drainage and water management. In authorized PL 566 projects within the region, multiple purpose reservoirs provide about 171,000 acre feet of storage for uses other than flood prevention (1967 base year). These other uses include municipal and industrial, irrigation, recreation, fish and wildlife, and low flow augmentation. Under the CO program, the USDA has installed channels for drainage and flood prevention, tidal dikes, diversions, waterways, and farm ponds for flood prevention, irrigation, recreation, fish and wildlife, fire protection, livestock, and rural domestic use.

METHODOLOGIES AND ASSUMPTIONS

Establish Study Area

The Coordinating Committee delineated the NAR into six Subregions which are divided into 21 Areas (or Basins). Each of the 21 Areas coincide with large hydrologic units (Figure F-1). The ad hoc Work Group on Plan Formulation divided the 21 Areas into 50 Subareas.

Existing Data

Wherever possible use was made of existing data, records and reports. Data from ongoing studies of the Susquehanna River, Connecticut River, and James River were used. The Potomac River Report material was updated so as to be comparable to the other 20 Areas. Information was taken directly from PL 566, and PL 534 work plans, and preliminary investigations (PI) for PL 566 feasibility. United States Geological Survey (USGS) topographic maps were used to delineate flood damage areas and for the determination of storage capacity in potential upstream reservoir sites.

Upstream Watershed Inventory

Wherever existing data, records and reports were not available Soil Conservation Service (SCS) field personnel made a reconnaissance inventory. They used already developed methods or those described below.

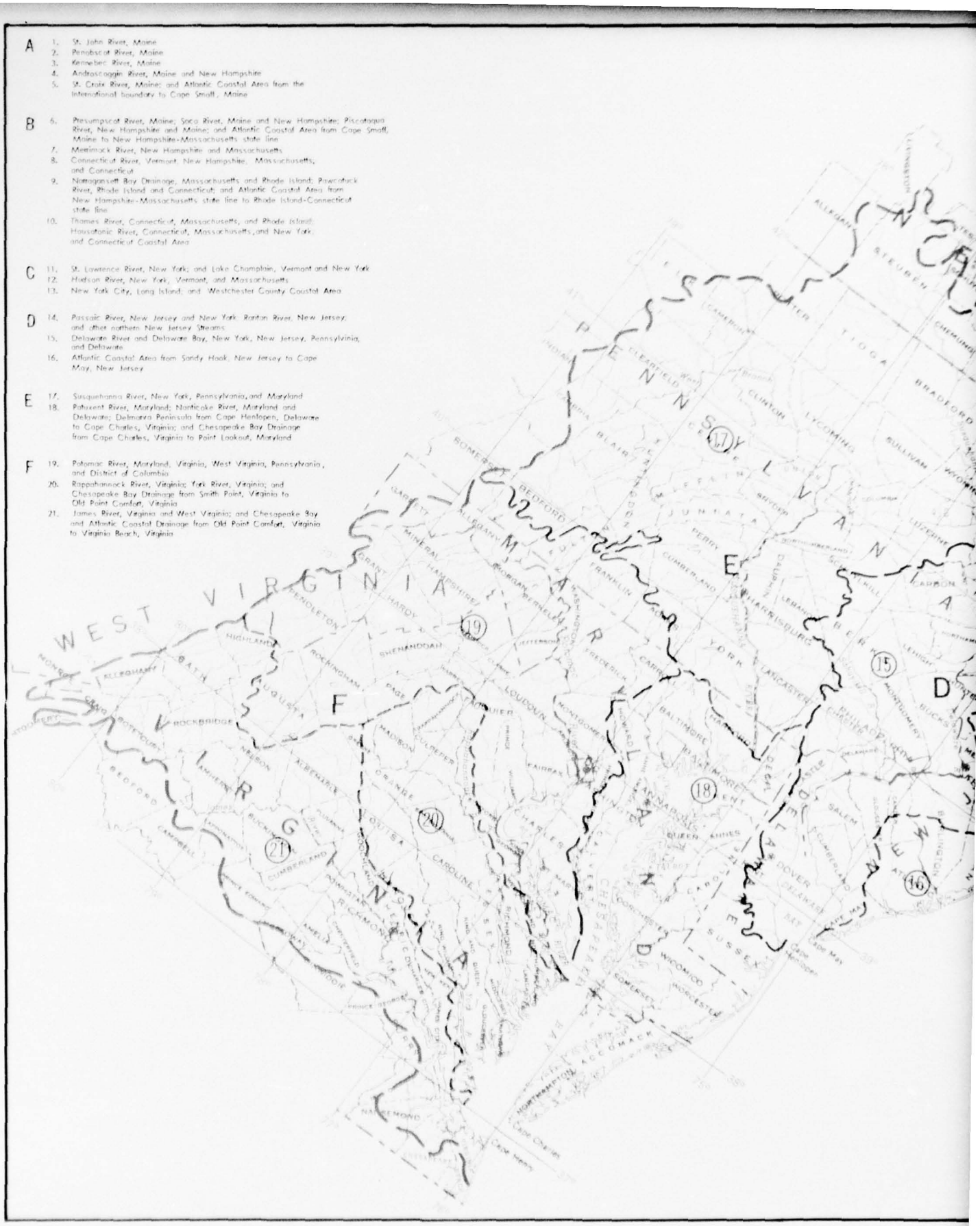
Inventory forms were developed to record information including area inundated, floodwater damage, floodwater damage reduction, storage in potential reservoirs, and costs for structural measures.

The Conservation Needs Inventory (CNI) watershed was the unit used in gathering the inventory data. The CNI delineation was developed as part of the National Inventory of Soil and Water Conservation Needs.(5) Each CNI watershed is a hydrologic unit or a combination of two or more hydrologic units with a drainage area not exceeding 250,000 acres.

The material in this appendix is presented by 21 Areas and 6 Subregions. The data for the Areas and Subregions were aggregated from the CNI units.

Delineating Flood Damage Area

Flood damage areas were delineated on USGS topographic maps. USGS stream gage records, aerial photos, soil survey maps, field reconnaissance, newspaper accounts, and knowledge of recent key floods were used as a basis for delineation of the damage area. The land use distribution within the damage area was determined by measuring from the USGS topographic maps.

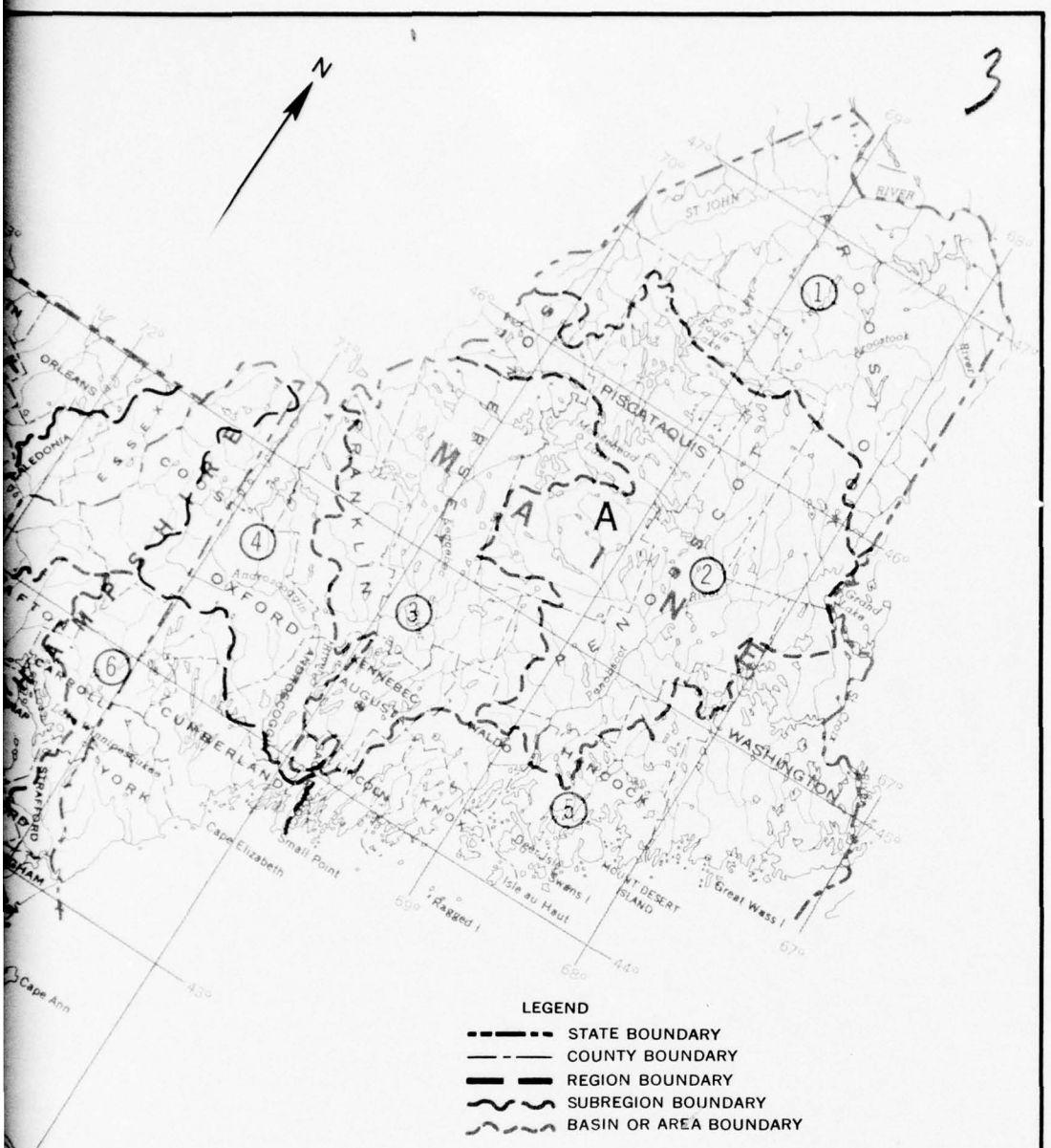

A
1. St. John River, Maine
2. Penobscot River, Maine
3. Kennebec River, Maine
4. Androscoggin River, Maine and New Hampshire
5. St. Croix River, Maine; and Atlantic Coastal Area from the International boundary to Cape Small, Maine
B
6. Presumpscot River, Maine; Saco River, Maine and New Hampshire; Piscataqua River, New Hampshire and Maine; and Atlantic Coastal Area from Cape Small, Maine to New Hampshire-Massachusetts state line
7. Merrimack River, New Hampshire and Massachusetts
8. Connecticut River, Vermont, New Hampshire, Massachusetts, and Connecticut
9. Narragansett Bay Drainage, Massachusetts and Rhode Island; Pawcatuck River, Rhode Island and Connecticut; and Atlantic Coastal Area from New Hampshire-Massachusetts state line to Rhode Island-Connecticut state line
10. Thames River, Connecticut, Massachusetts, and Rhode Island; Housatonic River, Connecticut, Massachusetts, and New York; and Connecticut Coastal Area
C
11. St. Lawrence River, New York; and Lake Champlain, Vermont and New York
12. Hudson River, New York, Vermont, and Massachusetts
13. New York City, Long Island, and Westchester County Coastal Area
D
14. Passaic River, New Jersey and New York; Raritan River, New Jersey; and other northern New Jersey Streams
15. Delaware River and Delaware Bay, New York, New Jersey, Pennsylvania, and Delaware
16. Atlantic Coastal Area from Sandy Hook, New Jersey to Cape May, New Jersey
E
17. Susquehanna River, New York, Pennsylvania, and Maryland
18. Patuxent River, Maryland; Nanticoke River, Maryland and Delaware; Delmarva Peninsula from Cape Henlopen, Delaware to Cape Charles, Virginia; and Chesapeake Bay Drainage from Cape Charles, Virginia to Point Lookout, Maryland
F
19. Potomac River, Maryland, Virginia, West Virginia, Pennsylvania, and District of Columbia
20. Rappahannock River, Virginia; York River, Virginia; and Chesapeake Bay Drainage from Smith Point, Virginia to Old Point Comfort, Virginia
21. James River, Virginia and West Virginia; and Chesapeake Bay and Atlantic Coastal Drainage from Old Point Comfort, Virginia to Virginia Beach, Virginia
PENNSYLVANIA
WEST VIRGINIA
MARYLAND
VIRGINIA
DELAWARE
NEW JERSEY
NEW YORK

NORTH ATLANTIC
REGIONAL WATER RESOURCES STUDY

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

October 1968

25 0 25 50 75 100 Miles



LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- REGION BOUNDARY
- SUBREGION BOUNDARY
- BASIN OR AREA BOUNDARY

FIGURE F-1

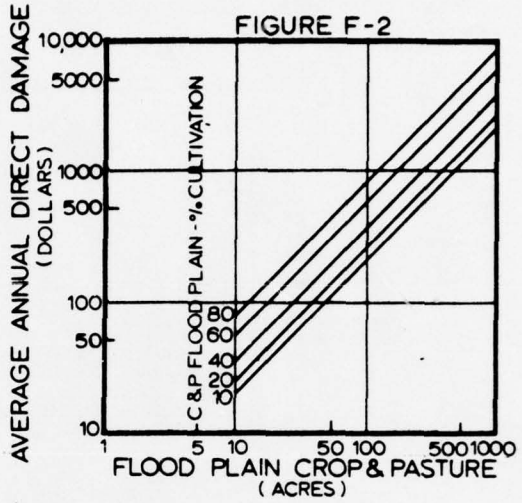
USDA-SCS-HYATTSVILLE, MD. 1970

Floodwater Damage Evaluation

Floodwater evaluation guides were used in determining damage values for crop and pasture, residences, farm buildings, and structures and contents for industrial, commercial, and institutional establishments. Transportation, utilities, and other damage values were based on judgment of personnel in the areas.

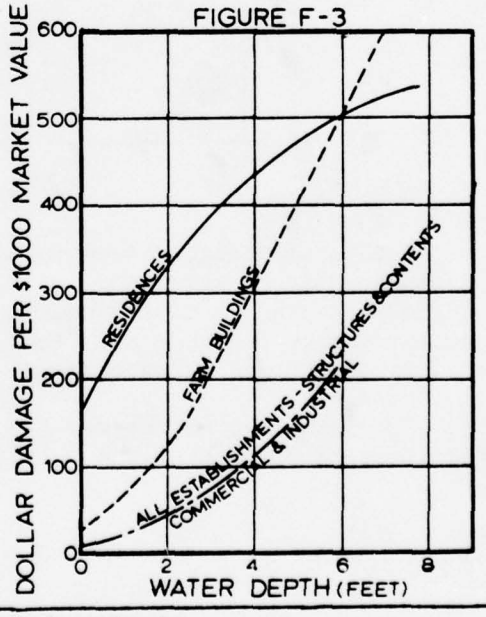
Crop and Pasture. The average annual damage was calculated from a family of curves showing acres of flood plain in crop and pasture and percent being cultivated versus Average Annual Damage. This family of curves was derived from monthly damages weighted by the percent distribution of damaging storms.

FIGURE F-2



Residences. Damage values[1] per market value of residences for various water depths were obtained from several Corps of Engineers damage schedules, Little Schuylkill Watershed schedules, and from Stanford Research Institute Studies.(6) These values were plotted and a curve was drawn (Figure F-3). Using this curve and the market value of the residences, the total damage for a specific flood frequency was calculated.

FIGURE F-3



Farm Buildings. Figure F-3 was used to determine the dollar damage[1] per $1000 market value of farm buildings. Using this curve and the market value of the farm buildings the total damage for a specific frequency storm was calculated.

Structure and Contents for All Establishments. Establishments include retail, wholesale, personal service, manufacturing and contracting. Figure F-3 was replotted and extrapolated from a curve developed by the Stanford Research Institute.(6) The dollar damage is based upon

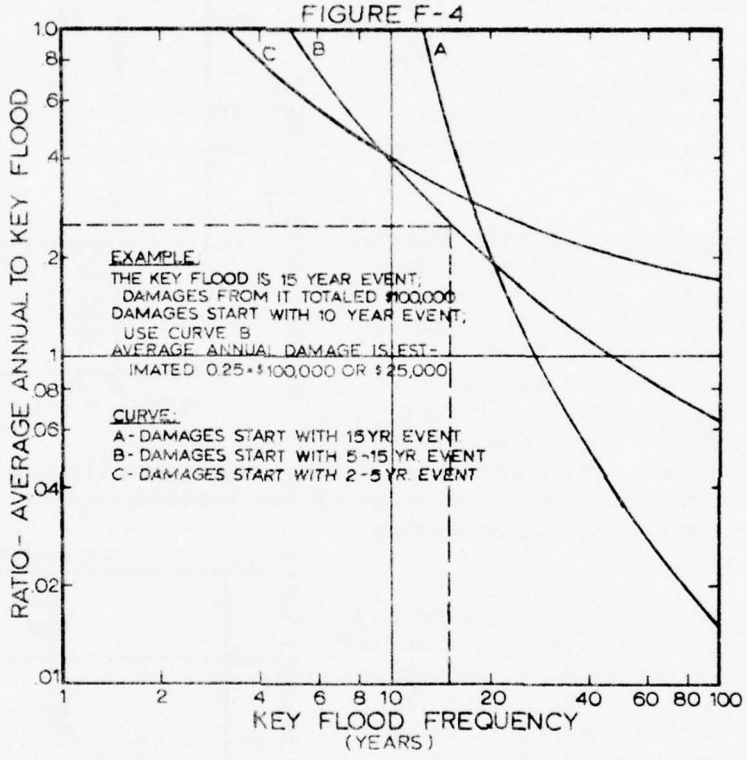
1/ Includes damages to structures and contents.

value of structure and contents. Because the damage to property value ratio varies so greatly, this curve was used only when it was impossible to get more accurate data.

Present Average Annual Flood Damage

The average annual damage for crop and pasture was determined directly from Figure F-2. The average annual damage for other than crop and pasture can be determined using Figure F-4. Figure F-4, which was developed from studied projects, is a plotting of the ratio of average annual damage to key flood damage versus key flood frequency.

FIGURE F-4

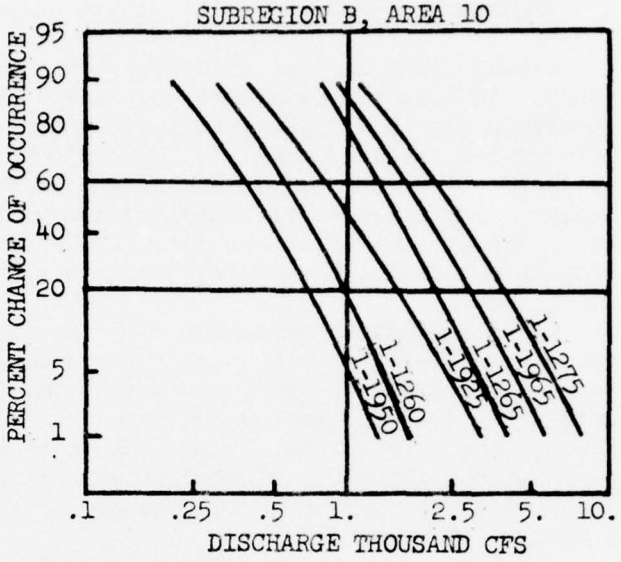


The total dollar damage associated with the key flood, the frequency of the key flood, and the frequency at which flooding begins are used to determine the average annual damage. The total dollar damage from the key flood was estimated using the methods described under Floodwater Damage Evaluation.

The frequency of the key flood was determined using one or a combination of both of the following two methods:

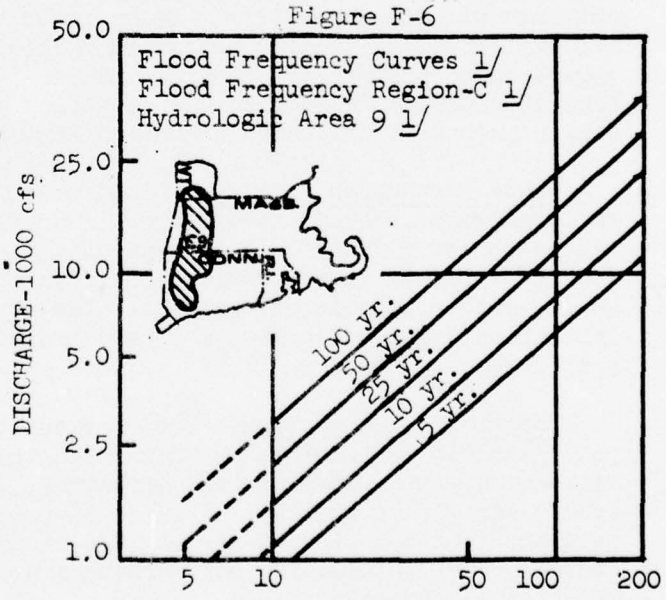
(1) Discharge-frequency curves were developed for selected USGS stream gages. The curves were plotted using a gamma distribution. Figure F-5 is an example of the plotted curves for Area 10.

FIGURE F-5
DISCHARGE-FREQUENCY CURVES
FOR SELECTED U.S.G.S. STREAM GAGES
D.A. 5-150 sq. mi.
SUBREGION B, AREA 10



(2) Curves were adapted from USGS Water Supply Papers.(7) They show the relationship between the drainage area and the flood discharge for a family of curves of any recurrence interval from 5 to 100 years. Figure F-6 shows an example of a family of curves for a part of Area 8. Each family of curves is for an area which is homogeneous with respect to flood-frequency characteristics. They were used to estimate the magnitude of a flood of any selected frequency between 5 and 100 years (or the frequency of a flood of known magnitude) for any site in the NAR for which the drainage area is 5 square miles or larger, on any upstream tributary not materially affected by regulation, diversion or usable storage.

Figure F-6



1/ Adapted from Magnitude and Frequency of floods in the U.S., Part 1A, USGS Water-Supply Paper 1671.

The frequency at which flooding begins was determined by one of the above two methods and experience of field personnel.

Engineering Analysis of Structure Sites

Actual field surveys of sites were beyond the scope of the study. In lieu of field surveys, USGS topographic maps were used to obtain the needed physical facts concerning a given site. The information obtained from the USGS topographic maps for each site included the bottom elevation, length of top of dam, shape of the valley, area of contours, improvements within the impoundment area, and drainage area above the dam. The smaller limit of drainage area investigated was usually 5 square miles.

To approximate the storage capacity of a site, a stage-storage curve was developed by measuring three or four contours and using average end areas to obtain volumes. The three or four computed points were plotted on log-log paper and a straight line was drawn through the points. On the same sheet of graph paper a stage versus surface area curve was plotted to make it possible to determine the relationship of volume of storage to surface area for a particular stage.

Sediment Storage. The volume of sediment to be stored was based on the amount of sediment expected to accumulate over a period of 50 years. In the region it varied from 0.15 to 1.25 watershed inches. This was based on experience of field personnel and on previously studied projects. Sediment volume in acre feet was determined by multiplying watershed inches by the drainage area in square miles times a constant conversion factor of 53.3. The acre feet of sediment determined the elevation of the permanent pool in single purpose flood water retention structures.

Flood Prevention Storage. Flood prevention storage provides for temporary impoundment of excess runoff. The volume of storage needed for effective flood prevention varies from 3 to 5 watershed inches of runoff in the region. This was based on experience and the results of completed projects. The storage for effective flood prevention usually involved a level of protection against the 100 year frequency flood.

Beneficial Use Storage. Use of water in beneficial storage could include irrigation, municipal and industrial, fish and wildlife, recreation, rural domestic and livestock, low flow augmentation, power, and visual quality. A Water Resources Development computer program[8] using selected stream gage data was used to develop yield-storage relationships for determining a practical upper limit of beneficial storage.

FIGURE F-7
ANNUAL RUNOFF

Data taken from HA-212 Annual Runoff in the Conterminous United States by Mark W. Busby, published by the U.S. Geological Survey.

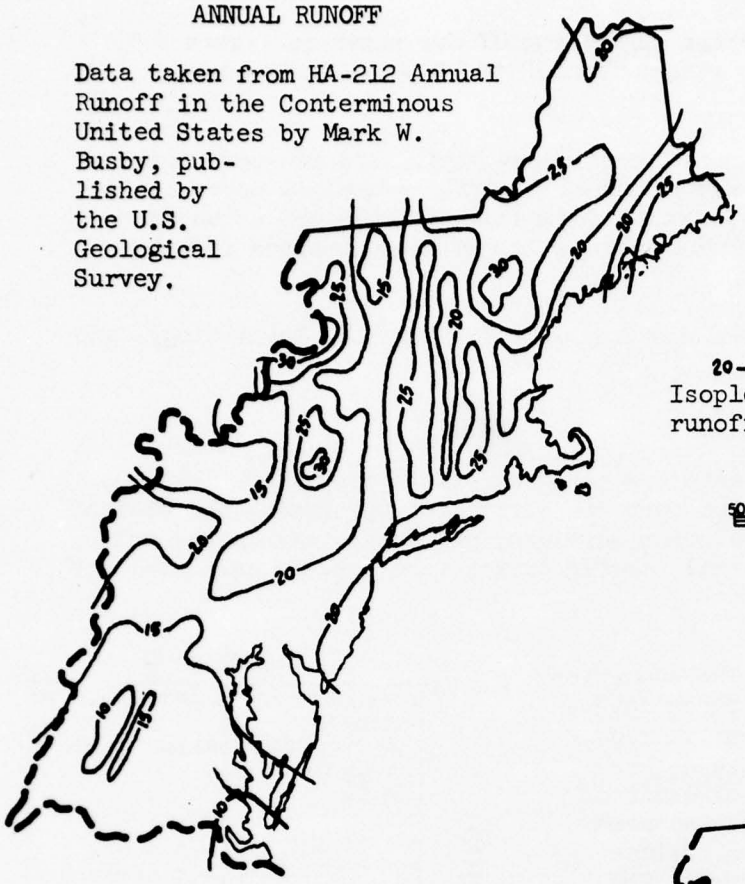
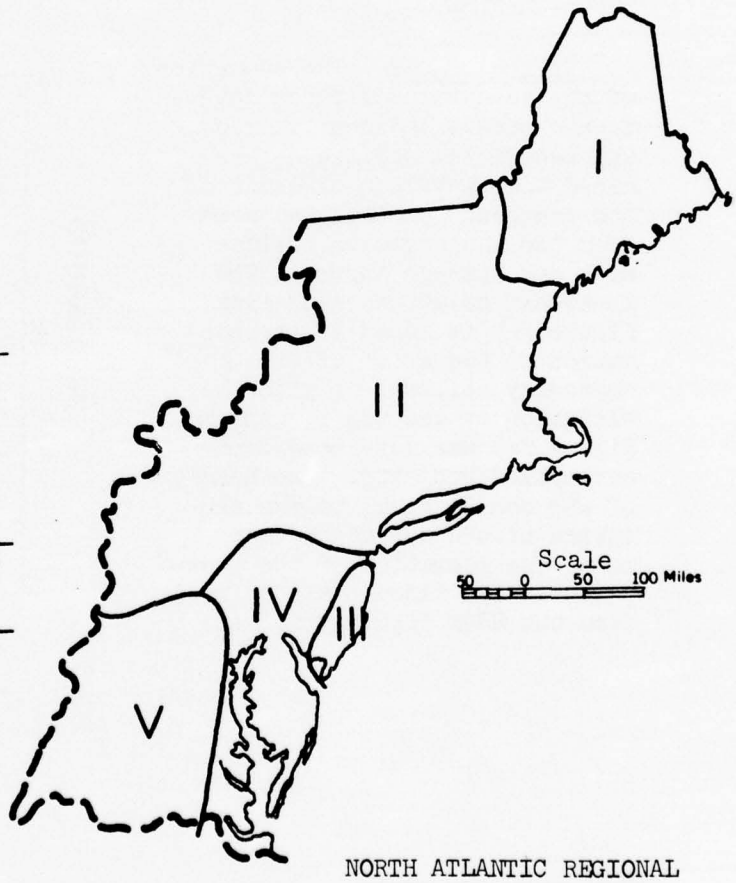


FIGURE F-8
RESERVOIR STORAGE REQUIREMENT IN % OF AVERAGE ANNUAL RUNOFF.
(1% chance of shortage - 80% draft rate)

Region	Storage Required in % of Average Annual Runoff
I	75
II	55
III	40
IV	65
V	90



NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY

Isopleths of average annual runoff are shown in Figure F-7. Figure in the Region ranges from 10 to 30 watershed inches.

The maximum practical continuous draft rate is approximately 80 percent of the average annual runoff. Practical upper limits of water storage requirement for beneficial use are shown in Figure F-8. Beneficial storage in the Region ranged from 8 to 19 watershed inches.

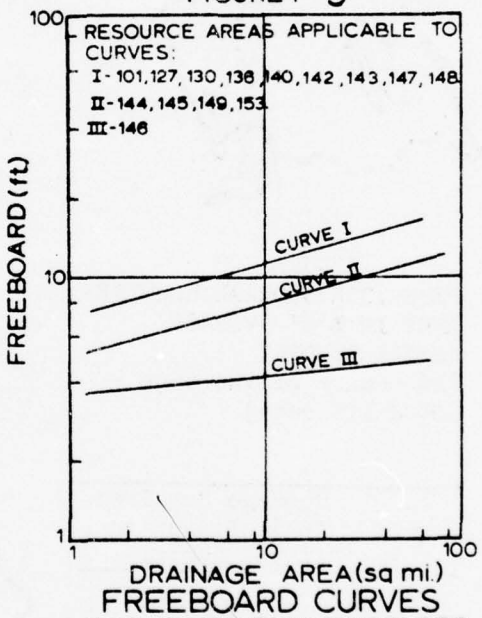
For further detail see Appendix C, "Climate, Meteorology, and Hydrology".

Structure Site Costs

Structure cost data are based on prices prevailing in 1970. The total installation cost was arrived at by summing the cost of construction, installation services, and lands, easements, and rights-of-way. Several working curves were used to help evaluate these items.

Height of Dam. The summation of the acre feet of flood detention storage, sediment storage, and beneficial storage determined the elevation of crest of the emergency spillway as read from the stage versus surface area and storage curves. The freeboard height as read from Figure F-9 is added to the elevation of the crest of the emergency spillway to give the elevation of the top of the dam. Figure F-9 was developed from authorized projects. The height of the dam is equal to the elevation of the top of the dam minus the elevation of the lowest point in the flood plain as read from the USGS topographic map.

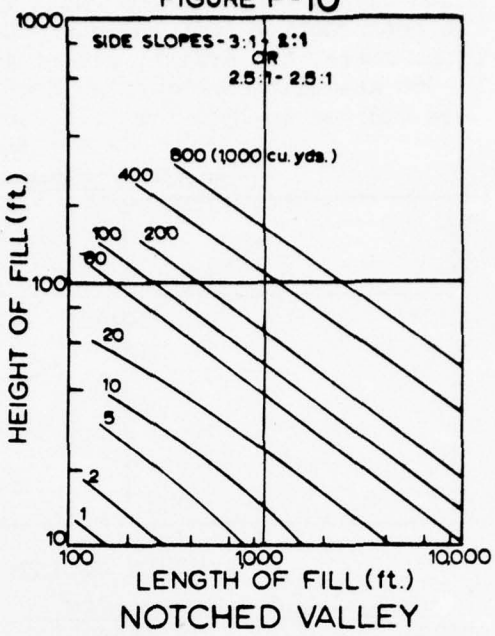
FIGURE F-9



FREEBOARD CURVES
FOR CLASS "C" STRUCTURES

Volume of Earth Fill. Figures F-10, F-11, and F-12 were used to compute the volume of earth fill in the dam. The figure or figures that were used depended upon the shape of the valley, i.e., notched, rectangular, parabolic, or an average of two of the figures. The length and height of the earth fill were needed. The length of the top of the dam was read from a USGS topographic map using the calculated elevation of the top of the dam. The determination of the height of the dam was discussed in the previous section.

FIGURE F-10



NOTCHED VALLEY

FIGURE F-11

PARABOLIC VALLEY

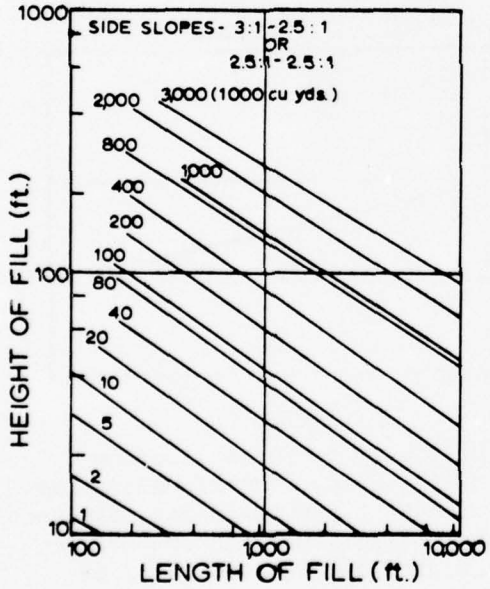
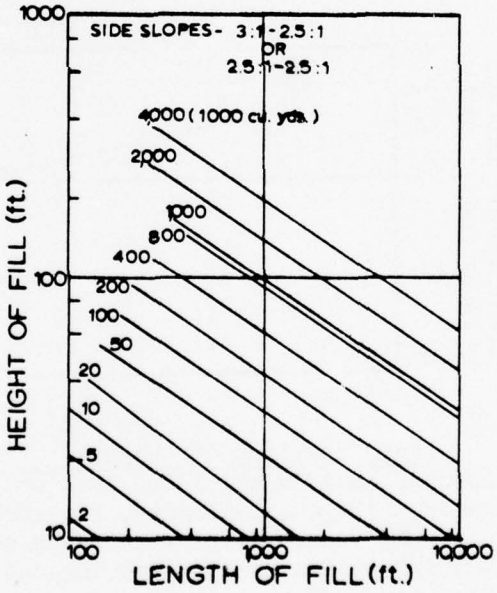


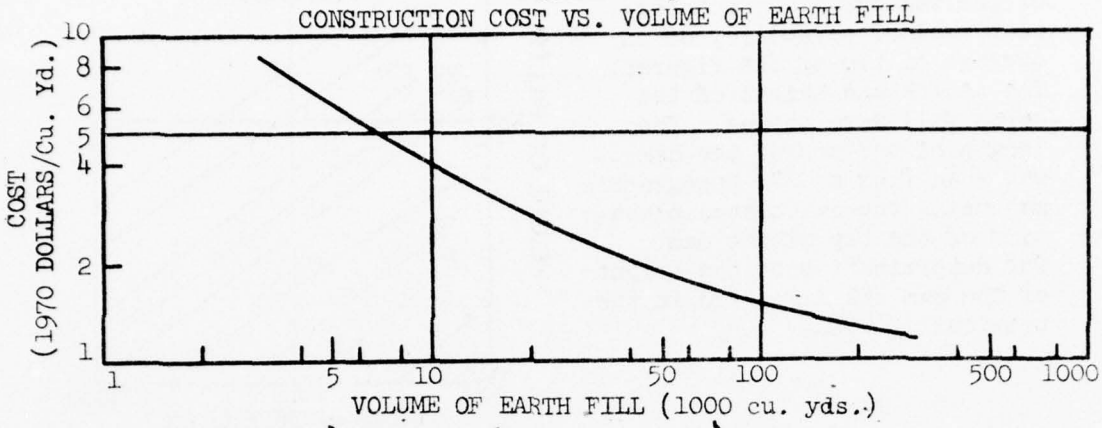
FIGURE F-12

RECTANGULAR VALLEY



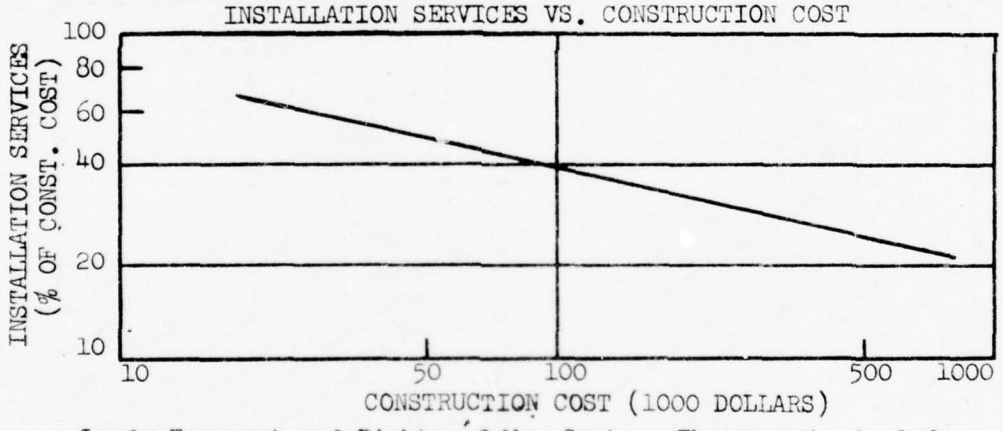
Construction Costs. Unless local situations dictated the use of other costs, construction costs were calculated using Figure F-13. The construction cost includes the cost for earth fill, concrete, pipe, gates, toe drains, clearing, etc. These costs are based on PL 566 as-built construction costs. They were adjusted to 1964 and were updated to 1970 for this study.

FIGURE F-13
CONSTRUCTION COST VS. VOLUME OF EARTH FILL



Installation Services Costs. Installation services include costs for geologic investigations, engineering surveys, final designs, supervision and inspection, and administrative overhead. Figure F-14 was used to calculate the installation services cost, as a percent of construction cost. The data to construct this curve were compiled from PL 566 work plans within the NAR.

FIGURE F-14
INSTALLATION SERVICES VS. CONSTRUCTION COST



Land, Easement and Rights-of-Way Costs. These costs include cost of land in the flood pool and dam site area, cost of relocating roads, bridges, buildings, railroads, costs of rights-of-way, easements, etc. The cost values were based on local experience and/or prepared tabular estimates obtained through consultation with the Corps of Engineers. The easement area for the flood pool is read from the stage-area curve using a stage equal to 2 feet above the crest of the emergency spillway.

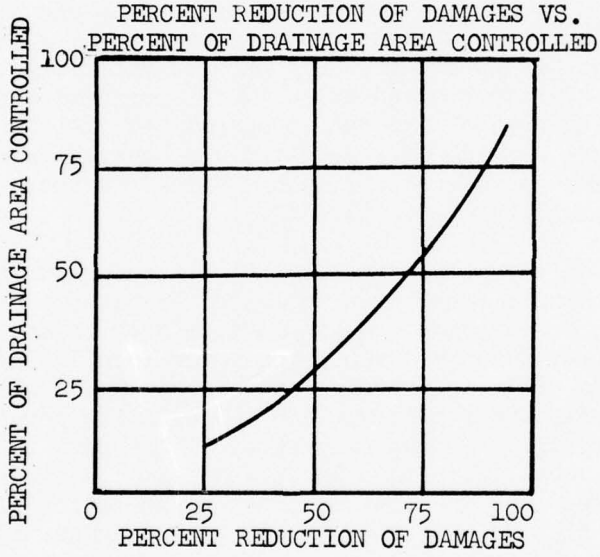
Average Annual Cost. The total average annual cost is equal to the operation and maintenance costs plus the amortized total cost. The total cost is equal to the sum of the construction cost, installation services costs, and the land, easement and rights-of-way costs. The total cost was amortized over 100 years at 5-1/8 percent interest. The average annual cost by purpose was determined using the "Use of Facilities Method" of allocation.

Present Flood Damage Reduction Benefits

Information from PL 566 watershed work plans developed in the NAR was summarized to determine the relationship between damage reduction (benefits) and percent of drainage area controlled by structures. Figure F-15 is a summary of this analysis.

The percent of control determined from USGS topographic maps by measuring the drainage area of the structure sites above the damage reach and the drainage area to the damage center. The damages in the reach were determined as described earlier in the Methodologies and Assumptions.

FIGURE F-15
PERCENT REDUCTION OF DAMAGES VS.
PERCENT OF DRAINAGE AREA CONTROLLED



Project Classification

The inventory data for each CNI watershed were tabulated and summarized in Tables F-4 through F-9. These tables contain general watershed data, pertinent flood plain information, benefit and costs and upstream structural measures for each of the 21 Areas and 6 Subregions. Each CNI watershed was classified as to whether it was Not Evaluated, an Authorized Project, a Potential Flood Prevention Project, or a Potential Development. These categories are summarized by Region in Table F-3.

(1) Not Evaluated. These are watersheds which are urban, subject to tidal inundation or are in downstream areas on main stems. They are the responsibility of the Corps of Engineers. Structural measures on upstream tributaries in these watersheds were shown but the damages and benefits were not calculated. Forest preserves and remote upstream areas were not evaluated.

(2) Authorized Projects. These are watersheds where projects have been authorized by Congressional action under the following authorities:

(a) The Flood Control Act of 1944, PL 534, as amended, gives to the USDA responsibility in 11 selected watersheds in the United States for watershed investigations and for planning and installing measures to reduce runoff and erosion and to retard stream flow. The upper portion of the Potomac River Watershed (Area 19) was one of 11 authorized selected watersheds. Within Area 19, 10 subwatersheds have been planned and works of improvement are being installed.

(b) "Pilot" demonstration small watershed projects were authorized under an appropriation item in the Department of Agriculture Appropriation Act, 1954 (PL 156 - 83d Congress). This Act authorized the USDA to conduct surveys, investigations and research and to carry out preventive measures, including but not limited to operations, method of cultivation, the growing of vegetation and changes in use of land on 54 watershed projects in the United States. Seven of these projects are in the NAR.

(c) USDA was given the responsibility for administering the Watershed Protection and Flood Prevention Act of 1954, PL 566, as amended. These projects are for the purpose of flood prevention and water management, including such purposes as drainage, irrigation, recreation, municipal and industrial water supply, fish and wildlife development, water quality, and other purposes. The USDA in cooperation with federal, state and local agencies makes preliminary investigations and assists local organizations in preparing a work plan. As of 1967, 92 PL 566 projects have been authorized in the NAR.

(3) Potential Flood Prevention Projects. These watersheds are projects which exhibit flood prevention benefit-cost (B:C) ratios of 0.3:1 or greater under present conditions. These projects deserve further study for possible flood prevention justification under an early action program. Following are some of the reasons for choosing a B:C ratio of 0.3:1 rather than unity.

(a) General evaluation procedures were used. A detailed study may show a higher B:C ratio.

(b) The "Use of Facilities" method was used to allocate the cost to flood prevention. The choice of another method may favor flood prevention.

(c) The benefits were based on present damages and did not account for potential growth in the flood plain.

(d) Downstream damage reduction benefits were not included in the evaluation.

(4) Potential Developments. If a watershed did not fall into the above three categories it was classified as a potential development. These watersheds exhibited a flood prevention B:C ratio of less than 0.3:1 under present conditions. Thus it was assumed that there is no flood prevention justification under an early action program. However, there is potential storage available for beneficial uses. Beneficial use storage is that storage over and above the sediment and flood prevention storage in the potential developments and the potential flood prevention projects.

Damage Projections

Damages by type were estimated at the time of the inventory (1965-1967). Damages and damage projections are based upon 1970 dollars. Future potential damages were determined by weighting agricultural and nonagricultural projections in proportion to present damages. The weighted damage projection factors appear in Table F-1. The projections assume people will continue to use the flood plain similar to past patterns.

Agricultural Damage. The projection of agricultural damage is based upon expected crop yield increases(9) and cropland distribution for each area (Tables G-21 through G-28 in Appendix G). The distribution of cropland in the flood plain is assumed to be similar to the distribution of cropland for the entire area. Using the expected increased yields and the cropland distribution, an average agricultural damage projection factor was obtained for the target years 1980, 2000 and 2020.

Nonagricultural Damage. Nonagricultural damageable property values were assumed to increase in direct proportion to the increased wealth of an area. Personal income was used as a growth indicator of reproducible wealth. The nonagricultural damage projection factors were based on Office of Business Economics (OBE) projections of personal income. A more detailed explanation of assumptions can be found in Appendix E.

Personal income is comprised of per capita income and population. Per capita income indicates improvements to and content value in existing structures. Population indicates rate of building. Thus, damageable property values with no new construction in the flood plain were assumed to increase in direct proportion to per capita income.

Projections with Structural Flood Prevention Measures. Present average annual damage is the total average annual damage less damage reduction of authorized projects. The present average annual damage multiplied by the projection factor in Table F-1 yielded the potential damages without further flood prevention measures for the target years 1980, 2000 and 2020. The projected damages are shown by Area in the Subregional Summaries.

TABLE F-1

WEIGHTED DAMAGE PROJECTION FACTORS

Subregion and Area	1980	2000	2020
Subregion A			
1	1.53	2.71	5.43
2	1.45	2.65	5.17
3	1.42	2.27	4.17
4	1.50	2.72	5.55
5	1.25	2.49	4.98
Subtotal A	1.42	2.52	4.93
Subregion B			
6	1.56	2.84	5.76
7	1.54	2.93	5.93
8	1.54	2.97	6.06
9	1.53	2.85	5.63
10	1.58	3.04	6.28
Subtotal B	1.55	2.93	5.93
Subregion C			
11	1.37	2.12	3.73
12	1.46	2.66	4.89
13	-	-	-
Subtotal C	1.44	2.56	4.67
Subregion D			
14	1.50	2.74	5.16
15	1.42	2.37	4.27
16	1.43	2.32	4.23
Subtotal D	1.44	2.44	4.44
Subregion E			
17	1.54	3.03	6.35
18	1.35	1.81	2.50
Subtotal E	1.41	2.18	3.66
Subregion F			
19	1.63	3.05	6.10
20	1.51	2.63	4.87
21	1.57	2.91	5.66
Subtotal F	1.60	2.98	5.87
REGION	1.50	2.65	5.04

Present average annual damage minus damage reduction with Potential Flood Prevention Projects gave what the 1966 damages would have been if these projects had been installed. By applying the projection factors to this damage, damages with Potential Flood Prevention Projects in place were determined for the target years 1980, 2000 and 2020.

Present average annual damage, minus damage reduction, with Potential Flood Prevention Projects and Potential Developments gave what the 1966 damages would have been if all potential upstream structural flood prevention measures were installed. The projection factors were applied to this damage to yield the remaining damages with all potential upstream structural flood prevention measures in place for 1980, 2000 and 2020. These projected damages are shown by Area in Subregional Summaries.

Objectives

Alternative objectives were considered in developing needs and solutions in plan formulation. The rationale for national efficiency, regional development, and environmental quality objectives appears in Appendix T, "General Program and Alternatives".

National Efficiency (NE)

Reduction of direct and indirect floodwater damages wherever and whenever justified are considered essential to the nation's economic growth and development.

Regional Development (RD)

Monetary benefits from a regional, state, or local viewpoint are used in economic justification. These benefits include increased spending by project beneficiaries; value of income provided to unemployed and underemployed labor and use of other resources required for project construction, operation and maintenance; and added area employment.

Environmental Quality (EQ)

Protection of the entire flood plain provides benefits not measurable in monetary terms. Prevention of loss of life, increased economic opportunities for low-income families, improvement of health aspects, preservation of unique areas, and maintenance of delicate ecological systems are examples. It was assumed in this study that optimum protection would result from management of the entire flood plain and watershed protection. Upstream multipurpose reservoirs would provide water surfaces where these surfaces are required to enhance the visual quality of the environment.

Extent and Timing of Structural Flood Prevention Measures

Within the scope of this study planning a program of watershed development for the time frame years 1980, 2000 and 2020 was a major concern. The determination of the extent and timing of groups of flood prevention projects must be made differently than justification for individual watershed projects which are related to specific needs. A program relates itself to needs which may be satisfied over time and space.

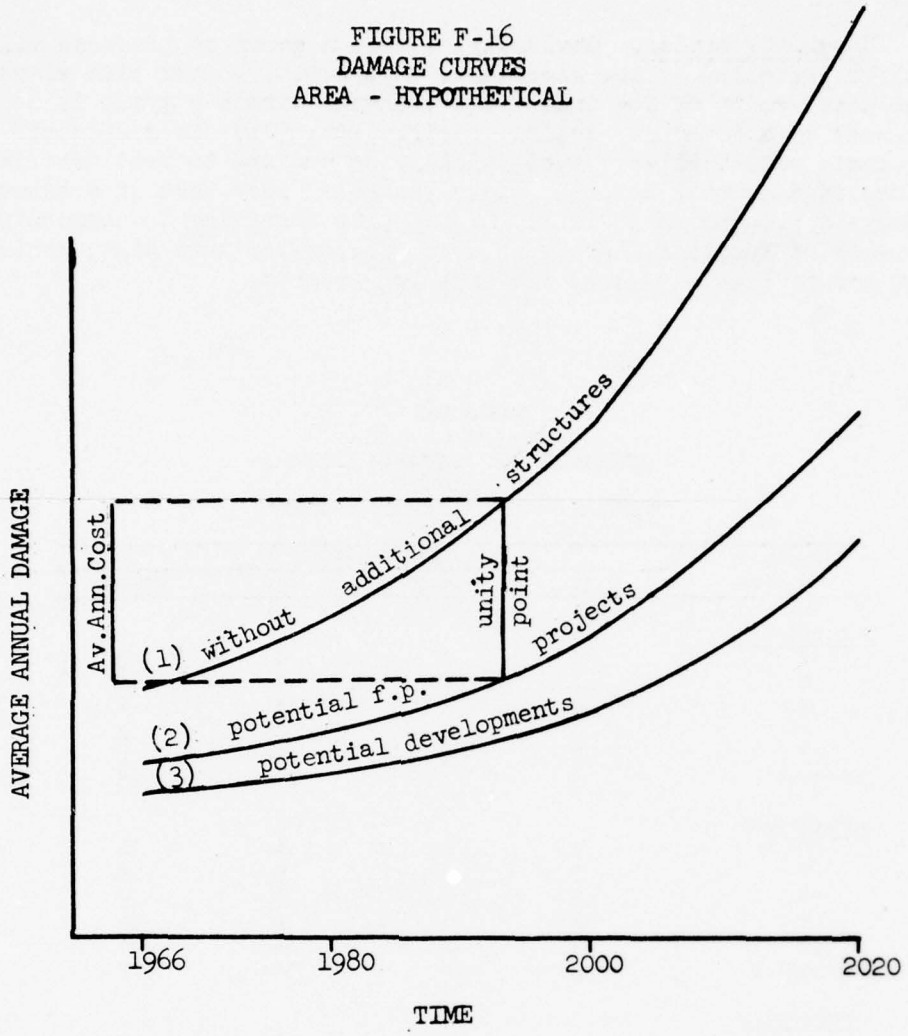
The rate at which projects would be constructed depends upon: (a) economic justification, and (b) community action. The most practical (economic) time was established by determining the point in time at which benefits exceeded costs for groups of projects. The timing of individual projects within the group was determined by using a community action factor.

The following is a brief outline of the procedures that were used to indicate potential structural flood prevention measures by time frame years.

Economic Justification

Three curves of average annual damage versus time were developed for each Area. They showed damages: (1) without additional structural measures (with Authorized Projects), (2) with "potential flood prevention projects", and (3) with "potential flood prevention projects" and "potential developments" for the target years 1980, 2000 and 2020. The damage curves are illustrated in Figure F-16. The curves for (2) and (3) assume all projects and/or developments were in place in 1966.

FIGURE F-16
DAMAGE CURVES
AREA - HYPOTHETICAL



Damage reduction benefits attributable to "potential flood prevention projects" are found by measuring the vertical distance between the first and second curve. Similarly, the distance between the second and third curves represents damage reduction benefits attributable to "potential developments".

Assuming that price relationships affecting both benefits and costs remain the same over time, average annual costs expressed in 1970 in dollars would not change.

Damage reduction benefits are easily analyzed in relation to the average annual costs by using the curves developed earlier. The point in time when costs-to-benefits equals unity is found by moving the vertical line representing the appropriate average annual cost from right to left until it closes the span between applicable damage curves (see illustration). Thus, economic justification of a group of projects and timing is readily coordinated.

Community Action. Obviously, all of a group of projects will not be installed at the same time. Distribution over time around the unity point of the individual projects within a group is accomplished by a community action co-efficient. (10) Over 20 socio-economic variables were statistically determined to best describe rates of community action. These variables were used in a discriminant analysis program which rated the projects according to community action or ease of adoption. Projects were categorized into high, medium or low groups (Table F-2) by the computer program.

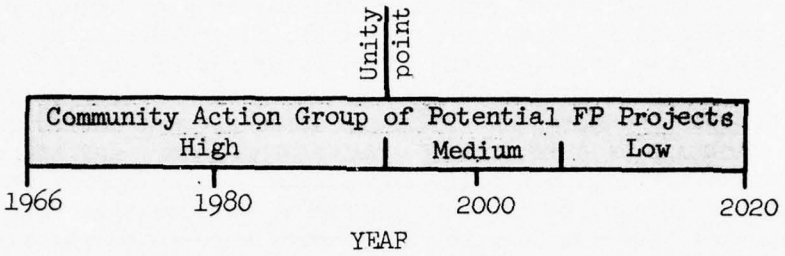
TABLE F-2

PROBABILITY OF COMMUNITY ACTION
TO IMPLEMENT
POTENTIAL FLOOD PREVENTION PROJECTS

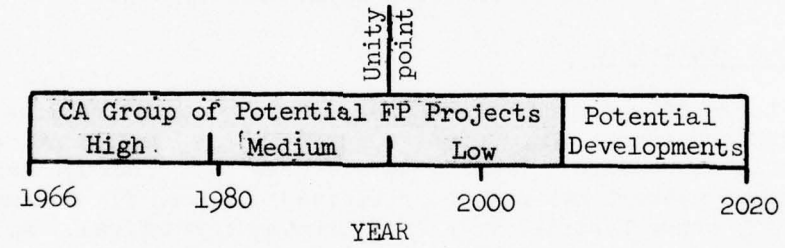
Subregion and Area	NUMBER OF PROJECTS			
	High	Medium	Low	Total
Subregion A				
1	1	0	2	3
2	1	0	4	5
3	0	0	8	8
4	1	0	1	2
5	0	0	8	8
Subtotal A	3	0	23	26
Subregion B				
6	5	0	9	14
7	5	6	5	16
8	6	1	6	13
9	12	1	19	32
10	5	11	11	27
Subtotal B	33	19	50	102
Subregion C				
11	3	0	5	8
12	7	1	1	9
13	0	0	0	0
Subtotal C	10	1	6	17
Subregion D				
14	1	0	7	8
15	4	6	16	26
16	0	0	0	0
Subtotal D	5	6	23	34
Subregion E				
17	5	3	5	13
18	53	37	0	90
Subtotal E	58	40	5	103
Subregion F				
19	16	13	6	35
20	1	7	1	9
21	5	9	13	27
Subtotal F	22	29	20	71
REGION TOTAL	131	95	127	353

Potential projects were allotted to time spans. Total time span varied around the unity point with the high, medium, and low group projects spread in time according to the objective. These spans, or portions thereof, were related to the time frame years for project formulation.

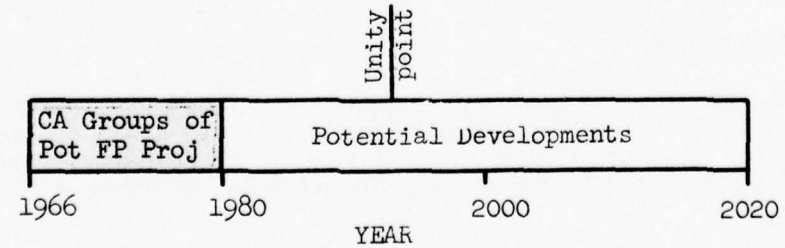
Toward the national efficiency objective, the total time span was assumed to be twice the present to unity. Those projects in the high group were placed in the first half; the medium and low group in the last half. To illustrate:



Regional benefits as increased spending by project beneficiaries and utilization of unused local resources are in addition to damage reduction benefits used to determine the unity point. The earlier economic justification and incentives to encourage community action are assumed to shorten the time span. Toward the regional development objective, the total time span was assumed to be half again the present (1966) to the unity point. Those projects in the high group were placed in the first third of the time span; in the medium group, the middle third and the low group, the last third. To illustrate:



Toward the environmental quality objective, landscape quality constraints rather than the economic unity point was used to determine time spans. Where additional water surfaces are needed, all potential flood prevention projects were placed in the earliest time frame. Developments were placed into the later time frames. To illustrate:



Because of physical and budgetary constraints it was deemed practical to determine the timing of projects differently if the costs-to-benefits equaled unity before 1980. The projects in the high group were placed in the time frame 1966-1980; and medium and low groups in the time frame 1980-2000. Area 18 is another exception; the projects in the high group were placed in the time frame 1966-2000, and the medium group in the time frame 2000-2020. Project timing described is for the national efficiency objective.

Flood Plain Management

Otner measures for preventing flood losses are: flood plain zoning, acquisition, land use management, flood warning systems, evacuation, flood proofing, and flood insurance of specific properties. The extents and combinations of these measures vary widely from one watershed to another. These measures were not evaluated in this analysis because of the scope of the study, and the present state of the art does not allow for a readily usable evaluation of the benefits and costs. It is significant to note that even if all the potential upstream structural measures were to be installed there would be considerable remaining damages. Flood plain management appears to be the solution to controlling these remaining damages.

Flood plain management demands vary according to objectives. Urban and urban amenity lands not protected by structural measures are the demands of the national efficiency and regional development objectives. Management of all the flood plain is the demand of environmental quality objective. The plain subject to high damages would be managed by 1980, low to medium damages by 2000, and the remainder of the flood plain would be managed by 2020.

Watershed Protection

In terms of hydrologic processes, land treatment reduces overland flow and runoff and increases interception, infiltration, and soil-moisture storage. Peak flows are reduced. Although land requiring treatment may not be justified solely on flood damage reduction, other benefits make land treatment practical. Acreages requiring treatment and feasible to treat are listed in Appendix G "Land Use and Management". Acreage requiring treatment in project watersheds are the demand of the national efficiency and regional development objective. All land requiring treatment and feasible to treat is the demand for the environmental quality objective.

RELATION TO OTHER PARTS OF THE REPORT

Flood Prevention

Upstream flood damages and measures for flood prevention have been compiled in this Appendix. Damages on main stems and major tributaries and the methods for alleviating these damages are covered in Appendix E, Flood Control and Water Management on Main

Stems and Major Tributaries. In regard to the total flood damage picture, there would show in some instances a need for upstream structural measures; in other instances main stem structural measures; and still in other instances a combination of both. There would show in other instances a need for flood plain management and in many instances a combination of structural measures and flood plain management, depending upon physiographic, climatological, hydrologic, economic, and social conditions. This will be resolved in plan formulation.

Water Management

The needs for water covered in other appendices include irrigation, navigation, pollution abatement, recreation, aesthetic and cultural, fish and wildlife, power, municipal and industrial, and rural domestic and livestock. In addition to flood prevention storage, potential upstream reservoirs could provide considerable storage to satisfy water needs.

Any number of uses compatible with the physical limitations of a reservoir site and the available water supply may be combined in a multiple purpose reservoir. The combination of uses may be a number of separate uses added together or there may be joint use of the available water storage.

If feasible sites are available but the storage capacity is inadequate to satisfy all needs completely, then an allocation of the storage to the various purposes must be made as equitable as possible, the adopted allocation being a compromise between the various uses. This will be reconciled during plan formulation. It will be reported in Appendix T and in the Main Report.

Watershed protection consists of proper land use and land treatment. Protected watersheds yield higher qualities and often higher quantities of water. They reduce surface runoff, improve moisture infiltration into the soil, increase ground water recharge, and decrease sediment from polluting the streams and reservoirs. Land use and treatment are discussed in Appendix G, Land Use and Management.

Price Base and Interest

Values of land and property, construction and service costs were adjusted to a common price base to make them comparable to data presented in other appendices. Projected monetary values are also expressed in terms of 1970 dollars.

An interest rate of 5-1/8% was used to amortize costs. If the interest rate was increased from 5-1/8% to 6-1/8%, the suggested number of projects for national efficiency objective by 1980 would decrease from 94 to about 70. Higher interest rates would cause use of poorer quality, shorter life construction materials and higher maintenance costs.

REGIONAL SUMMARY

PRESENT STATUS

Flooding

Total property damage in the NAR for the period 1925-1967 averaged in excess of $26 million annually. (3) For this same period loss of life averaged about 11 persons annually. The average annual property damage has increased to $192 million (as of 1966 expressed in 1970 dollars). The increase is because of the deflated dollar and of changed and more intensive use of the flood plain.

About 29 percent of the damages occurs in the upstream flood plains. Floodwater and sediment damage to agricultural crops, farmlands, and buildings amounts to $18 million; damage to nonagricultural properties amounts to $37 million.

Area Inundated. Total area inundated by the 100 year frequency flood in upstream watersheds of the Region, excluding Area 13, is approximately 6.1 million acres (Table F-3). Area inundated by the 50 year and the 10 year frequency flood is approximately 5.6 million acres and 4.3 million acres respectively. Of the flood plain, 34 percent is in crop and pasture, 36 percent is in forest, and 30 percent is in urban and miscellaneous.

The range of percent area inundated in crop and pasture is less than 1 percent in Area 5 to 50 percent in Area 17. The range of percent area inundated in urban and miscellaneous is 7 percent in Area 21 to 80 percent in Area 9. The range of percent area inundated in forest is 4 percent in Area 9 to 78 percent in Area 1. Area inundated as a percent of total Area ranged from less than 1 percent in Area 1 to 48 percent in Area 18.

Types and Amounts of Damage. The average annual flood damage by Area for cropland, other agriculture, residential, commercial and industrial, transportation and other is indicated in Tables F-4 to F-9. . The present average annual damage (total damage minus reduction of authorized projects), excluding Area 13, is equal to $55 million. Of this 32 percent is agricultural, and 68 percent is nonagricultural. Area 5 with 1 percent and Area 18 with 87 percent, indicate the range in agricultural damage in the NAR. The range of present average annual damage of all types is $ 0.06 million in Area 1 to $10.91 million in Area 18. The present average annual damage in dollars per acre of area inundated ranges from less than $1 in Area 16 to $80 in Area 10. The average for the Region is $9.

In upstream areas there are a total of 109 authorized PL 566, PL 534 and Pilot watershed projects which include 492 dams with about 527,000 acre feet of flood storage, and 1,474 miles of channel improvement. These projects will reduce present average annual

damage by $8.9 million leaving a damage of $4.0 million. Present average annual damage in upstream areas outside of watershed projects is $50.8 million.

Water Management

In the Authorized Projects there is included about 171,000 acre feet of storage for uses other than flood prevention in 160 multiple purpose reservoirs. A 4,000 acre feet is stored for irrigation use. An estimated 400,000 people living in 54 communities are served by 55,000 acre feet water supply. Another 90,000 acre feet of water for recreational and fish and wildlife uses creates 8,700 acres water surface. An estimated 4 million annual user days are provided on these surfaces. Additional recreational benefits incidental to multipurpose projects are enjoyed on 72,000 water surface acres created in 255 reservoirs. Another 22,000 acre feet is stored for other uses including low flow augmentation.

As of 1967 under the Conservation Operations program of the USDA technical assistance was provided for the installation of about 6,800 miles of diversions, 8,000 miles of tile, and 14,000 miles of open main ditches for drainage and flood prevention. Also installed were about 70,000 ponds for flood prevention, irrigation, recreation, fish and wildlife, livestock, rural domestic, and fire protection.

PROBLEMS AND NEEDS

Flooding

Floods damage property, disrupt households, hamper business, pose health hazards, tangle transportation, mar the environment, and cause loss of life. Changed and more intensive use of over 6 million upstream flood plain acres subject to inundation, will cause flooding to be an even greater problem in the future.

Present Damages. Presently the average annual flood damage in the Region is about $55 million. Flood damages in their entirety cannot be economically eliminated. Even if all Potential Flood Prevention Projects structural measures had been installed in 1966, the damages remaining would be about $30 million or 54 percent of the present average annual damages. This is due to (1) the location of structural measures in relation to the damage center, (2) the absence of structural measures, and/or (3) the level of protection (economics) afforded the damage areas.

PL 566 measures are usually designed to protect urban and residential areas against the 100 year frequency flood, and agricultural areas against a flood of 2 to 10 year frequency depending upon the crop being flooded. From experience it has been found that these levels of protection coincide with economic and social desires. Thus it can be seen that even if structural measures can be found to control 100 percent of the drainage area above

the damage point there still would be damages occurring from the storms exceeding the designed level of protection.

Future Damages. If no additional flood prevention measures were installed, the present average annual flood damages of $55 million would increase to $82 million in 1980, $145 million in 2000, and $277 million in 2020. (Table on page F-30.) If new construction were restricted from the flood plains, the average annual damage may increase to $70 million, $98 million, and $150 million in 1980, 2000 and 2020 respectively. If all the suggested flood prevention structural measures were installed based on the methodologies for the extent and timing toward the national efficiency objective, the average annual damages remaining would be $73 million, $103 million, and $185 million in 1980, 2000 and 2020 respectively. Reduction and remaining damages for other objectives are shown in Table F-3.

Water Management

Water withdrawals are expected to be four times greater in 2020 than they are now. Instream needs will continue to increase. An additional million water surface acres are necessary to satisfy water oriented recreational, fish and wildlife, and visual quality needs. Upstream reservoirs can help satisfy these water storage and surface needs. Demand for beneficial use storage in upstream reservoirs will be determined in the NAR Supply Model.

Minimum irrigation water requirements for agriculture, institutional and industrial lawns, and golf courses in the Region for 1980, 2000 and 2020 are 762,000 acre feet; 1,013,000 acre feet; and 1,238,000 acre feet respectively. About 42 percent of these requirements is for agricultural irrigation. More than 60 percent of the water for irrigated cropland comes from constructed reservoirs. Consideration of irrigation storage use in multipurpose reservoirs is especially important in Areas 1, 9, 13, 15, 16 and 18.

Rural domestic and livestock water requirements in the Region will increase from 178,533 mgd in 1964 to 490,755 mgd in 2020.(11) An estimated 688 rural communities and small towns need water supply systems. In addition, 743 upstream reservoirs are needed (12) to help meet municipal and industrial water supply needs.

Recreation and fish and wildlife needs within the next 50 years range from .4 to 2.2 additional million surface acres of fresh water.1/ These water surfaces provide those desiring outdoor water oriented activities the opportunity of 940 million visitor days.1/ The same water surfaces enhance the visual quality of the landscape in areas 12 through 21.

Instream flows can be augmented by water released from upstream reservoirs. Increased stream flows could dilute waste discharges

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1/ Compiled from NAR Phase III Plan Formulation data.

TABLE F-3
UPSTREAM FLOOD DAMAGES AND STRUCTURAL MEASURES
NORTH ATLANTIC REGION SUMMARY

Time or Year	Project Classification	Watersheds: No.	Watersheds: Area 1000 Sq.Mi.	Flood Plain 1000 Ac.	Flood Damage	Damage Reduction	Remaining Damage	Average Annual Cost*: Flood Prev.	Other Uses	Total	Total Est. Cost	No. of Dams	D. A. above Dams Sq.Mi.	Storage: Flood-water 1000 ac. ft.	Storage: Other Uses 1000 ac. ft.	Channel Improvement 1000 Mi.
					Million Dollars											
PROJECT CLASSIFICATION																
1966	Not Evaluated	154	30	83				2	3	5	1	144	891	197	447	-
	Authorized PL 566-534	109	8	426	13	9	4	7	3	10	235	492	3030	527	171	1.5
	Potential Flood Prev. Projects	353	40	3717	35	24	11	23	42	65	1166	1279	11575	2175	4113	4.3
	Potential Developments	852	94	1946	16	2	14	33	86	119	2239	2194	23037	4042	9961	.6
	TOTAL 1/	1314	142	6089	64	35	29	63	131	194	3640	3965	37642	6744	14245	6.4
Present Damage																
1980					55											
2000					82											
2020					145											
					277											
SUGGESTED EXTENT AND TIMING TOWARD OBJECTIVE																
	National Efficiency 1980					9	74	7	13	20	366	407		681	1366	.1
	2000					42	104	16	31	47	473	561		880	1645	1.5
	2020					92	185	23	42	65	327	306		615	1124	1.7
	Regional Development 1980					18	65	12	21	33	590	673		1057	2089	2.1
	2000					46	100	20	36	56	408	456		797	1414	2.1
	2020					94	183	26	49	75	347	283		535	1169	.1
	Environmental Quality 1980					13	70	12	49	37	666	759		1207	2042	.6
	2000					24	122	21	56	77	738	626		838	2192	.3
	2020					51	226	29	80	110	620	479		732	1759	.3

1/ Excludes Not Evaluated
Damages and average annual costs shown in the table are cumulative; other values are incremental.
Price Base 1970.
* Amortized at 5-1/8% interest over 100 years and operation and maintenance.

and treatment plant effluent. Improved water quality and uniform flows encourage game fish populations; stream angler days would be increased. Low flow augmentation would help restore the aesthetic landscape enhanced by streambanks with clean flowing water. Increased flows could enable recreational boatsmen to enjoy white-water canoeing and pleasure boating and shippers to use navigation.

The problems and needs connected with water management will be covered in other appendices. The average runoff in the Region is 163.0 bgd or 19.95 inches per year. The fresh surface water withdrawals for all purposes is only 12 percent(13) of the average annual runoff. The average availability of water is abundant, but its usefulness is limited by uneven geographic distribution, large fluctuations in supply, and poor quality in some locations.

MEANS TO SATISFY DEMANDS

Flooding

Flooding can be prevented or controlled with structural measures and/or nonstructural measures. Structural measures include dams with flood prevention storage, channel improvement, and dikes, levees, and tide gates. Nonstructural measures are comprised of watershed protection and flood plain management.

Structural Measures. The table on page F-3 indicates the extent and timing of structural measures in Potential Flood Prevention Projects. The installation of 1,279 dams with 2,175,000 acre feet of flood prevention storage and 4,253 miles of channel will reduce the annual flood damage in 2020 by $120 million. The extent and timing of potential flood prevention structural measures by Area and by objective is indicated on plan formulation tables in the Subregional Summary.

Watershed Protection. In addition to structural measures, land treatment and management will provide flood damage reduction benefits. Forty percent of the Region's 105 million acres needs treatment. Land treatment measures include diversions, terraces, waterways, stripcropping, cover cropping, contour farming, and afforestation. Management includes application of lime and fertilizers, and conservation cropping systems. Land treatment and management can account for 2 to 5 percent reduction in flood damages. In the NAR if all the land were treated and managed properly, damage reduction could amount to about $8 million in 2020. Land use, changes, treatment and management are covered in Appendix G.

Land treatment and management contribute significantly to controlling erosion and the resulting sediment. This is covered in detail in Appendix Q.

Flood Plain Management. Flood plain management is used to curtail additional damageable properties, preserve and improve ground water recharge areas, provide aesthetic and scenic amenities, protect fish and wildlife resource, enlarge recreational areas, and improve visual quality of the environment. Flood plain management practices include flood plain zoning, flood proofing, flood warning systems, and evacuation.

Restricting new construction from the flood plain may reduce damageable property growth by 57 percent. The estimate is based upon rates of building indicated by population growth; refer to Damage Projections on page F-17. Controlling land use changes, limiting intensity of flood plain use, and restricting improvements may result in reduction of present damages as well as to eliminating additional damageable property. Diverse flood plain management practices under varying conditions need to be compared with structural measures.

The amount of reduction in damage from total flood plain management was not analyzed in this study because of the engineering, economic and social problems in evaluation. Some questions to be answered are: How can the benefits and costs from nonstructural measures for flood prevention be evaluated? How is the cost of restricting flood plain development determined? What is the cost in each part of the flood plain? How will the cost vary throughout the project life? From which portions of the flood plain should development be excluded? Which kinds of development should be excluded? How can individual owners more effectively protect their property by flood proofing?

Nonstructural measures need to be evaluated as alternative or complementary considerations to structural measures. Even if all Potential Flood Prevention Projects structural measures were installed, nearly two-thirds of floodwater damage would remain. Nonstructural measures appear to be the only recourse for preventing this remaining damage.

Flood plain management plans need to be developed and implemented. A first step toward such a plan is delineation of the flood plain and of areas expected to be inundated by several frequency floods. Until detailed hydrologic studies can be completed, soil surveys may be used on an interim basis. Planners should consider: acquisition of the 10-year flood plain, eliminating new construction or substantial improvement in the 10 to 50-year flood plain, restricting construction in 50 to 100-year flood plain subject to builders' flood proofing plan and to the management plan, and broadening flood insurance (mandatory when any federal funds are involved) to include commercial and industrial properties.

Water Management

Storage. In addition to flood prevention storage in the Potential Flood Prevention Projects there is storage of 4.1 million acre feet for other uses. There are about 10.4 million acre feet of

Figure F-17
SCHEMATIC OF MULTIPURPOSE RESERVOIR

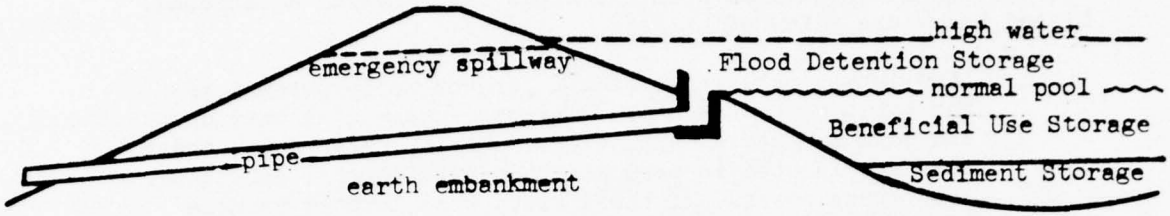
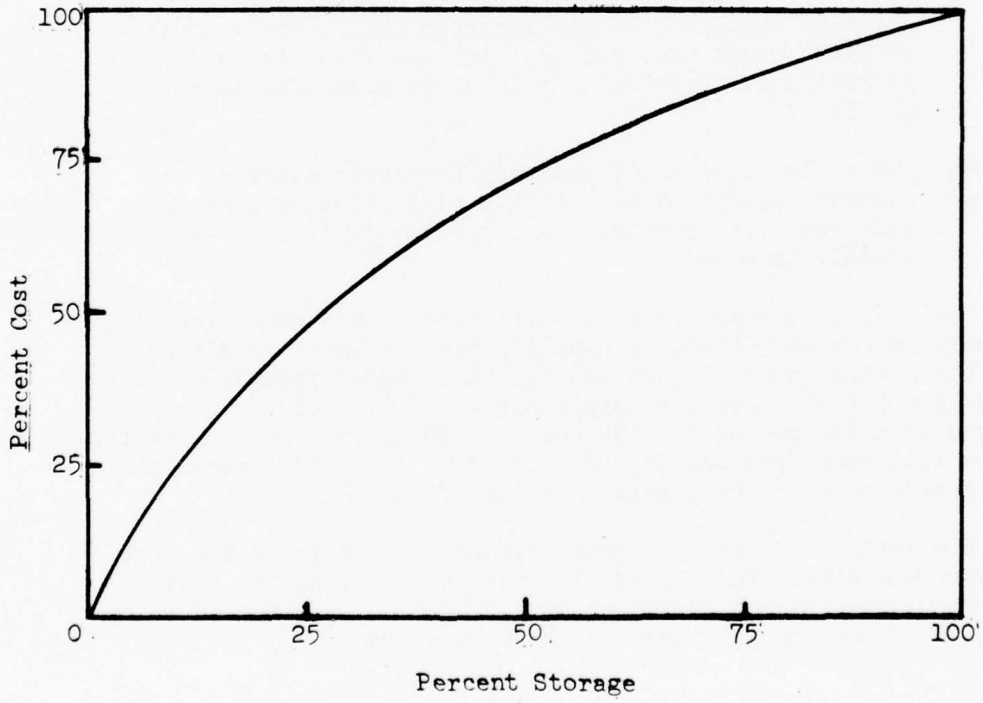


Figure F-18
PERCENT COST VS PERCENT STORAGE
UTILIZED IN UPSTREAM RESERVOIRS



storage for other uses in Potential Developments and Not Evaluated watersheds. The total available for water management in potential upstream impoundment is 14.5 million acre feet. This storage is the maximum practical development based on yield, topography and rights of way. The specific needs for water will be identified in other appendices.

Storage reservoirs in upstream areas have several advantages. Listed below are a few of these:

1. Landrights costs range from 2 percent to 50 percent of the total cost of a dam. This percentage will vary up and down in special situations. For the most part, these dams are located in predominantly rural areas, thus lower landrights costs. If these sites were located in more populated areas, the landrights costs could increase tenfold.

2. Water for rural domestic, municipal and agricultural use could be stored closer to the source of demand, thus reducing water distribution costs. Water not consumed will be available for re-use downstream. Pollution is often less of a problem in upstream areas resulting in lower water treatment costs.

3. The environment is enhanced by the distribution of water surfaces impounded behind upstream dams. These bodies of water would also provide fish and wildlife, and recreational opportunities in close proximity to the people.

4. The social aspects of upstream reservoir sites is another consideration. Little disruption of community life and transportation and service facilities is usually involved.

The cost of storage in reservoir sites in upstream areas varies greatly in the NAR depending upon location and site conditions. For the smaller sites (1,000 AF) the cost ranges from $150 per AF to $1,000 per AF. For the larger sites (25,000 AF) the cost ranges from $30 per AF to $150 per AF. In special situations the costs will vary from the aforementioned ranges. In general these costs were more in the central portion of the NAR.

The economy of scale is quite evident in analyzing the cost of an upstream site. When decreasing the storage from the maximum practical development to 20 percent of maximum practical development, the cost per AF increases on the average by 105 percent.

Ground Water. The extent of ground water development is discussed in Appendix D. Large land use shifts could affect the ground water supplies. Precipitation infoltrates pervious areas and percolates to the ground water. With these pervious areas being covered by residential and urban developments, shopping centers, parking lots and transportation systems, the precipitation will run off and not become available to recharge the ground water supplies.

Diversion. In general there should be little need to divert water to satisfy the needs in upstream areas. The flexibility in location of smaller impoundments and the availability of ground water supplies should satisfy most upstream needs.

Programs and Agency Activities in Upstream Water Resource Development

There are several ongoing programs and agency activities which would help satisfy the demands for flood prevention and water management in upstream areas.

Federal Agencies

Soil Conservation Service (SCS). Under the Conservation Operations (CO) program the SCS through Soil Conservation Districts (SCD) provides technical help to farmers, ranchers, suburbanites, urbanites, and other land users in a national soil and water conservation program. Approximately 97 percent of the NAR is in SCD. Conservation measures such as diversion terraces, grassed waterways, ponds, windbreaks, stripcropping, mulches and debris basins, help hold down the soil, conserve water, protect crops and livestock, and promote agricultural economy.

As part of the National Inventory of Soil and Water Conservation Needs, watershed project needs are inventoried. These needs are periodically updated and include drainage, irrigation, protection against floodwater, and sediment control.

The SCS administers PL 566, PL 534 and Resource Conservation and Development (RC&D) projects, and participates in comprehensive river basin planning.

Agricultural Stabilization and Conservation Service (ASCS). Under the Agricultural Conservation Programs (ACP) federal cost sharing assistance is provided landowners and operators to apply and install land treatment and structural measures. These practices reduce soil erosion and sedimentation, reduce runoff, and provide water storage for agricultural and rural use.

Farmers Home Administration (FHA). Grants and loans for the construction, improvement and extension of water and sewer systems are available to small rural communities. This assistance is given to promote the efficient and orderly growth of communities and to help control the pollution of water.

Agricultural Research Service (ARS). Hydrologic research is being conducted at several locations in the NAR. The studies vary by location and concern precipitation, snow melt, rainfall-runoff relations, flood peaks, water yield, channel stability, and sedimentation.

Economic Research Service (ERS). Research functions range from program-oriented applied research to research activity that is problem-oriented but not directly linked to the development of a specific program. The river basin studies contribution by ERS is an example of program-oriented applied research. In these studies an effort is made to provide reliable economic information to those responsible for programs to develop the water and related land resources. Two Type II and three Type IV studies are underway in the NAR.

Problem-oriented research includes but is not limited to studies of irrigation efficiency, laws and administrative rules as they affect resource allocation, land use through remote sensing and recreation evaluation. All of the above research functions are directed to develop useful and reliable information about natural resources, their use, control, development and conservation.

Forest Service (FS). About 2.3 million acres of land in the NAR are in federally owned National Forests. These areas are managed under the principles of multiple use and sustained yield of the forest resources: wood, water, wildlife, and recreation.

The Forest Service also conducts cooperative programs in fire and insect and disease control, flood prevention and river basin planning and forest management on state and privately owned forest lands within the NAR.

Research is conducted by the FS in the fields of water, timber, recreation, and wildlife habitat. Of particular interest to the NAR Study is the research being done in water yield improvement at the Hubbard Brook and Fernow Experimental Forests in New Hampshire and West Virginia and the cooperative federal, state and municipal water yield studies.

The Forest Service also cooperates with governmental agencies in the PL 566, PL 534 and other water resource development and governmental programs.

Corps of Engineers. Under existing authority the Corps of Engineers can, upon request from local interests, plan and design small reservoir projects. The field investigations, plans and design of these projects are carried out by the District Engineer, and he determines the justification for each invididual project in accordance with established criteria and procedures. If findings are favorable he can recommend construction of a project to the Chief of Engineers. If upon review by the Chief of Engineers the project is deemed advisable, allocation of funds within the limitations established by

by the 1948 Flood Control Act is then made for its construction. The Corps of Engineers participates in comprehensive framework and detailed river basin studies.

Federal Programs

Watershed Protection and Flood Prevention Act. The Congress of the United States enacted the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, as amended). This Act authorizes the Secretary of Agriculture to cooperate with states and local agencies in the planning and carrying out of works of improvement for the prevention of damages from erosion, flood water, and sediment and for furthering the conservation, development, utilization, and disposal of water. Responsibility for initiating projects under the Act rests wholly with local people through local organizations having authority under state laws to carry out, maintain, and operate works of improvement. The local organizations must acquire without cost to the federal government all necessary land rights except in cases where recreation, fish and wildlife, and water resource improvements are involved: defray the costs of operating and maintaining the works of improvement; obtain water rights; assume part of the costs of irrigation, drainage, recreation and fish and wildlife measures; bear all of the costs for measures serving other purposes; and obtain agreements from owners of at least 50 percent of the lands in the watershed above each retention reservoir to carry out recommended soil conservation measures. The Secretary of Agriculture may provide local organizations with technical, financial, and credit assistance in planning and installing needed water management and flood prevention measures. The planning is limited to watersheds or subwatershed areas of 250,000 acres or less, and to individual reservoirs with a maximum total capacity of 25,000 acre feet and maximum flood water detention capacity of 12,500 acre feet. In the event that the estimated federal contribution to construction costs exceeds $250,000 or the plan provides for structures with a capacity greater than 2,500 acre feet but less than 4,000 acre feet in a single structure, it must be approved by resolutions of the Committee on Agriculture and Forestry of the U. S. Senate and the Committee on Agriculture of the U. S. House of Representatives. Any plan involving a single structure of more than 4,000 acre feet of total capacity must be approved by resolutions of the Committees on Public Works of the Senate and House of Representatives. Section 6 of the Act authorizes the Department of Agriculture to cooperate with other federal and with state and local agencies to make investigations and surveys of watersheds of rivers and other waterways as a basis for the development of coordinated programs.

As of 1967 there are 91 Authorized PL 566 projects in the NAR.

The Flood Control Act of 1944, Public Law 534. PL 534, as amended, gives to the USDA responsibility in 11 selected watersheds for watershed investigations and for planning and installing measures to reduce runoff and erosion and to retard stream flow. The upper portion of the Potomac River Watershed (Area 19) was one of 11

authorized selected watersheds. The Potomac River Watershed is divided into 25 subwatersheds. Of these 10 have been planned and works of improvement are being installed.

Comprehensive River Basin Planning. As a means of strengthening coordination among all affected water and related land resource interests, the Congress enacted the Water Resources Planning Act (Public Law 89-80). This Act established the Water Resources Council, authorized establishment of river basin commissions, and provided for financial assistance to the states to increase state participation in coordinated planning of the nation's water and related land resources. Section 6 of PL 566 authorizes the Secretary of Agriculture to cooperate with other federal, state and local agencies in their investigations of watersheds, rivers, and other waterways to develop coordinated programs. The USDA is currently involved in two Type II and three Type IV studies.

Type II studies are in greater detail than Type I studies. They define and evaluate projects in sufficient detail to comprise a basis for authorization or implementation of those federal or federally assisted projects to be initiated in the next 10 to 15 years. These studies are coordinated by a river basin commission or other federal interagency - state coordinating organization. Studies recently completed within the Region are the Connecticut and Susquehanna River Basins.

Type IV studies are in the same detail as Type II studies. Type IV studies usually are state sponsored surveys of water and related land resources for all or part of a state or a river basin in which one or more federal agencies cooperate with the state or each other. Studies in progress within the Region are the James River and the Massachusetts Water Resources Study.

River basin surveys were completed for the Delaware River Basin, the Potomac River Basin, the New England-New York Inter-Agency Committee, and the Appalachian Water Resources Survey.

Resource Conservation and Development (RC&D). Under the Food and Agriculture Act of 1962, Congress authorized the Department of Agriculture to help rural communities improve their economy. RC&D projects were devised to meet this need. In these projects, local people and groups work together with USDA help to speed development of natural resources as a base for economic growth. RC&D projects are administered by the SCS.

This program provides technical, financial, and loan assistance on a limited basis to local legal sponsors in approved areas where acceleration of going programs of resource conservation, development, and utilization will increase economic opportunities for local people. The program provides local leadership with the opportunity to coordinate and utilize local, state and federal facilities and techniques more fully in planning and carrying out a balanced program of land conservation utilization and in determining alternate uses of land and water resources in open spaces. Included are technical

help on the conservation measures needed to reduce erosion, flooding, and sedimentation. As of 1967 there were six RC&D projects in the NAR which have been approved for planning or operations. They are East Central Vermont, St. John-Aroostook in Maine, South Central New York, North Country in New Hampshire, Endless Mountains in Pennsylvania, and Eastern Connecticut.

Needed Research

Following is a list of research needs for flood prevention and water management to better utilize and protect our water resources.

1. Further study in the field of small watershed hydrology. Locate many more stream gages in small watersheds (less than 5 square miles) to better evaluate the flood and water yield potential in upstream areas. Evaluate effects of urban development on runoff.

2. Develop evaluation procedures for determination of benefits and costs associated with flood plain management.

3. Development of procedures toward determination of the more equitable allocation of costs in multiple purpose reservoirs.

4. Further study into the salt water intrusion of ground water supplies.

5. Further study into evapotranspiration rates under maximum potential and under limited water supply conditions.

6. Continued work into the use of sewage effluent to satisfy specific water supply needs.

7. Development of procedures for evaluating projects toward alternative objectives.

CONCLUSIONS

Flooding

Damages in the Region have increased substantially over the past 20 years due mainly to more intensive use and increasing wealth in the flood plain. The trend toward increasing potential damages in the flood plain is expected to continue, assuming use of the flood plain will continue similar to past patterns.

If no additional potential flood prevention measures are implemented, average annual damages in the Region in upstream areas are projected to reach $277 million by the year 2020. Installation of potential structural flood prevention measures could result in average annual damage reduction of $129 million in 2020.

Alternatives in addition to dam and channel construction must be considered in reducing flood damages in upstream areas. Even if all potential structural flood prevention measures were installed in the Region by 2020 there would still remain an annual damage of $148 million. Flood plain management could help alleviate this problem, but further study is needed in the evaluation of benefits and costs.

Hydrologic studies are needed to delineate areas prone to flooding. Regional (basin) policies and criteria for use of these flood plains are needed until detailed plans can be developed. Needed reservoir sites in danger of being eliminated by urban construction need to be preserved until timely project development can take place.

Detailed flood prevention studies should be considered in Areas 7, 9, 10, 12, 15 and 18. This recommendation is based upon projected average annual flood damages in 2020 exceeding $10 million. Flood prevention plans incorporating structural measures, watershed protection, and flood plain management are needed to prevent these huge flood damages.

If detailed comprehensive river basin studies are initiated in Areas 6, 14 and 20 it is recommended that detailed flood prevention studies be considered. This recommendation is based upon projected average annual flood damage in 2020 exceeding $3 million but less than $10 million. Detailed comprehensive plans needed to solve water supply problems should include flood prevention measures.

There are 353 watersheds classified as "Potential Flood Prevention Projects". In areas not selected for comprehensive river basin studies, preliminary investigation of the "Potential Flood Prevention Projects" are needed to ascertain feasibility and local interest. These individual watershed investigations should consider multiple use of both structural and nonstructural flood prevention measures.

Areas 8 and 17 have recently been evaluated under Type II and 21 is now being evaluated under Type IV river basin studies. A study for Area 19 has been completed under a special Congressional authorization.

Water Management

There could be 14.5 million acre feet of water made available for uses other than flood prevention in potential upstream impoundments. Water surface of these potential impoundments would cover 922 thousand acres. This water will be considered for allocation to meet the needs developed in other appendices.

Federal cost sharing policies for particular purpose should be uniform. For example, land costs for flood prevention are borne by local people if a federally assisted project and by the federal government if a federal project.

Full site utilization needs to be encouraged. Justification procedures should include evaluating each purpose as the last increment. Full use of economies of scale will prevent underdevelopment of needed storage. Project purposes yielding long range and widespread benefits do not generally receive concerted local support. Units of governments, willing to exercise their authority to enter into financial arrangements and bear a large portion of the cost, are needed to satisfy widespread public demands.

Water quality, quantity, and surface demands vary with alternative objectives. Objectives change with time. The most desirable objective "mix" may be different a decade from now. To have a dynamic program, viable working tools and procedures are needed for periodically updated studies. The Demand-Supply Computer Models, resource interactions, and related land balances are such tools.

IV - SUBREGIONAL SUMMARY

SUBREGION A (Areas 1, 2, 3, 4 and 5)

Flooding

Area Inundated. Total area inundated by the 100 year frequency flood in the Subregion is approximately 377,000 acres (Table F-4). Of this, 3 percent is in crop and pasture, 66 percent is in forest land, and 31 percent is in urban and miscellaneous.

Area 5 has the greatest and Area 4 has the least total area inundated. The greatest and the least acreage inundated in crop and pasture is in Areas 3 and 1 respectively. The greatest and least acreage inundated in forest land is in Areas 5 and 4 respectively. The greatest and least acreage inundated in urban and miscellaneous is in Areas 5 and 4 respectively.

Area inundated as a percent of total area for the Subregion is 2. It ranged from less than 1 percent in Area 1 to 5 percent in Area 5.

Present Damages. The present average annual damage in the Subregion is approximately $0.9 million. It ranged from $0.1 million in Area 1 to $0.3 million in Area 3. Of the total, 14 percent is agricultural and 86 percent is nonagricultural. The percent agricultural damage ranged from 1 percent in Area 5 to 36 percent in Area 3.

The present average annual damage in dollars per acre of area inundated ranged from $1 in Area 5 to $10 in Area 4. The average for the Subregion is $2.

There are seven authorized PL 566 projects in upstream areas which will reduce present average annual damage by $0.17 million, leaving a damage of $0.01 million. Present average annual damage in the remaining upstream areas is $0.84 million.

Future Damages. If no additional flood prevention measures were installed, the present average annual flood damages of $0.9 million would increase to $1.2 million in 1980, $2.1 million in 2000, and $4.2 million in 2020 (Figure F-19). The range in annual damage in 2020 would be $0.3 million in Area 1 to $1.3 million in Area 4.

Extent and Timing of Flood Prevention Measures

Structural Measures. Suggested flood prevention structural measures involving installation of 77 multiple purpose dams with 302,800 acre feet of flood prevention storage at an average annual cost of $1.14 million will reduce annual flood damage by $2.80 million in 2020. The tables on pages F-46 through F-50 indicate the extent and timing of potential flood prevention structural

measures for each objective by Area. The installation of structures involving National Forest land will depend upon further analysis to determine compatability with National Forest purposes.

Flood Plain Management. Flood prevention plans for the 377,000 acre flood plain should include nonstructural measures or devices as an alternative, in combination or in addition to structural measures. With all potential flood prevention structural measures installed, the annual damages remaining would be $0.37 million, $0.66 million, and $1.29 million in 1980, 2000, 2020 respectively (Figure F-19). Flood plain management on 14,000 acres subject to high damages would reduce this remaining damage.

Water Management

In the seven authorized PL 566 projects there are included 58,300 acre feet of storage for uses other than flood prevention in multiple purpose reservoirs. As of 1967 under the CO program of the USDA technical assistance was provided for the installation of about 500 miles of diversions and 300 miles of tile for drainage and flood prevention. Also installed were about 2,200 ponds for flood prevention, irrigation, recreation, fish and wildlife, livestock, rural domestic, and fire protection.

In addition to flood prevention storage in the Potential Flood Prevention Projects, there is storage of 0.62 million acre feet for other uses. There are about 2.42 million acre feet of storage for other uses in the Potential Developments. The total available for water management in potential upstream impoundments is 3.04 million acre feet. The specific needs for water will be identified in other appendices.

Programs and Activities

PL 566. As of 1967 there were seven authorized PL 566 projects in the Subregion; four are in Area 1, one in Area 2, and two are in Area 4. Flood prevention storage of 48,400 acre feet and 58,300 acre feet of storage for other uses are included in 23 dams. The total estimated cost is $8.8 million.

RC&D. There are two RC&D's in the Subregion. The St. John-Aroostook RC&D project is located in Area 1. Forty-nine project measures have been proposed by the local people under the categories of Land Use and Treatment, Structural Measures, Associated Measures, and Supporting Measures.

A portion of the North Country RC&D project is located in Area 4. The objective of this project is to provide technical and financial assistance for the conservation and development of the water, land and related natural resources for the economic betterment of the area citizens.

New England-New York Inter-Agency Committee Report. All of Subregion A is included in this report. The principal authorization for the survey was Section 205 of the Rivers and Harbors and Flood Control Act approved May 17, 1950. The principal subjects are discussions of the river basins, economic development, storage and stream flow regulation, water supply, pollution control, flood control and drainage, power development, navigation and beach erosion, fish and wildlife, recreation, management of agricultural and forest lands, minerals and insect control.

SUBREGION A - AREA 1

Floods of 100 year frequency magnitude inundate about 29,505 acres. Land use in this flood plain consists of 400 acres of cropland and pasture, 23,095 acres of forest, 670 acres of built-up, and 5,340 acres of miscellaneous lands.

Floods presently cause an estimated $62,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $95,000 in 1980, $168,000 in 2000; and $337,000 in 2020.

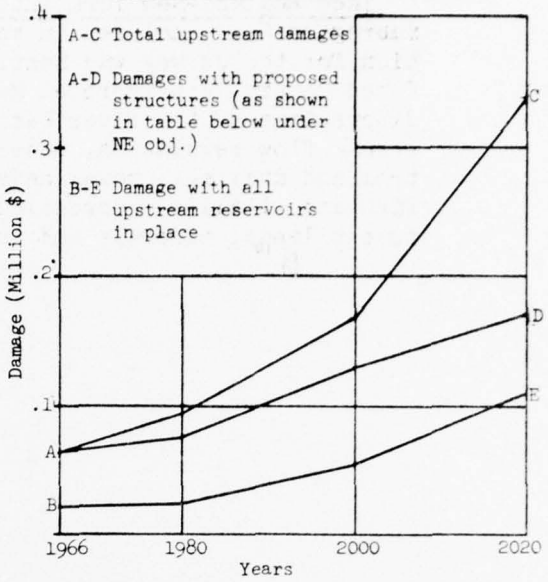
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 4,751,000 acres of land in Area 1, 2,108,000 acres require treatment and are feasible to treat. A net 183,000 acres will change use by 2020. Land use (1966) in the 18 watersheds consists of 240,000 acres of cropland, 25,000 acres of pasture, 4,240,000 acres of forest, 35,000 acres of urban, and 31,000 acres of other land.

Fully utilized, 33 potential upstream reservoir sites would have 414,300 acre feet of storage at an average cost of $66/acre foot. Allotment of the storage capacity is 27% for sediment and floodwater and 73% for other beneficial uses.

The release of 444 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 287 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
13,070 acres in 17 pools over 500 acres in size
2,310 acres in 8 pools 200-500 acres in size
600 acres in 4 pools 100-200 acres in size
80 acres in 2 pools less than 100 acres in size.
Average depths are 17 feet, 24 feet, 33 feet and 4 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 18 small watersheds in Area 1, 3 appear to warrant structural measures with flood prevention as a primary use. The 10 reservoirs with 22,400 acre feet of temporary storage could reduce flood damage by 49%. These 3 upstream watersheds deserve further study for early action projects.
Another 80,400 acre feet of temporary storage in 23 reservoirs could possibly be developed in 11 projects with flood prevention as a secondary or incidental purpose.

About 6% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 14,000 acres in the 10 year and 23,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment (1000 Ac.)	Flood Plain Mgt.	Structural Measures: Projects No.	Multi-purpose Dams No.	Storage: Total (1000 Ac.Ft.)	Flood Prev.	Channel Impr. (Mi.)	Cost: Structural Measures: One Time: Total ($ million)	One Time: Flood Prev.	Avg.Ann.* Total	Avg.Ann.* Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool 1000 Ac.
	1966	20		4	15	60	33	1						
NATIONAL EFFICIENCY														
	1980	43	1	1	4	12	8	-	1.5	.7	.1	.1	23	.4
	2000	-	1	-										
	2020	30	-	2	6	63	16	-	4.5	1.4	.3	.1	27	2.2
REGIONAL DEVELOPMENT														
	1980	43	1	1	4	12	8	-	1.5	.7	.1	.1	23	.4
	2000	-	1	-										
	2020	30	-	2	6	63	16	-	4.5	1.4	.3	.1	27	2.2
ENVIRONMENTAL QUALITY														
	1980	420	2	-										
	2000	844	23	-										
	2020	844	5	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION A - AREA 2

Floods of 100 year frequency magnitude inundate about 110,711 acres. Land use in this flood plain consists of 953 acres of cropland and pasture, 81,814 acres of forest, 546 acres of built-up, and 27,398 acres of miscellaneous lands.

Floods presently cause an estimated $114,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $165,000 in 1980; $301,000 in 2000; and $587,000 in 2020.

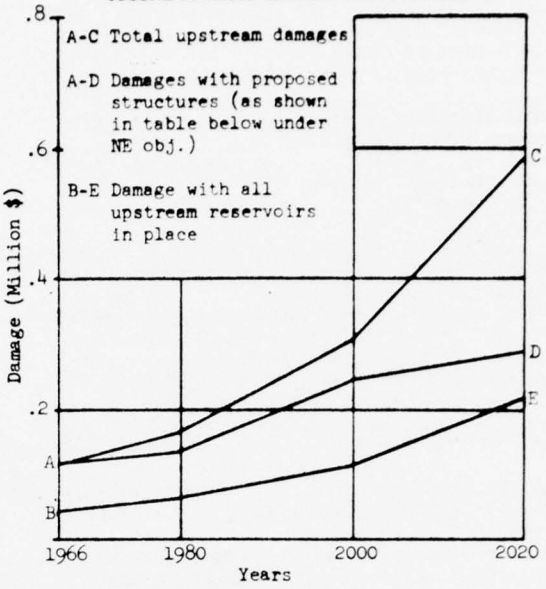
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 5,056,000 acres of land in Area 2, 2,068,000 acres require treatment and are feasible to treat. A net 222,000 acres will change use by 2020. Land use (1966) in the 41 watersheds consists of 196,000 acres of cropland, 41,000 acres of pasture, 4,659,000 acres of forest, 94,000 acres of urban, and 66,000 acres of other land.

Fully utilized, 51 potential upstream reservoir sites would have 862,000 acre feet of storage at an average cost of $63/acre foot. Allotment of the storage capacity is 27% for sediment and floodwater and 73% for other beneficial uses.

The release of 930 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 601 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
36,570 acres in 31 pools over 500 acres in size
6,860 acres in 18 pools 200-500 acres in size
320 acres in 2 pools 100-200 acres in size.
Average depths are 12 feet, 27 feet, 23 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 36 small watersheds in Area 2, 5 appear to warrant structural measures with flood prevention as a primary use. The 10 reservoirs with 42,300 acre feet of temporary storage could reduce flood damage by 52%. These 5 upstream watersheds deserve further study for early action projects. Another 169,500 acre feet of temporary storage in 41 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 2.2% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 54,000 acres in the 10 year and 91,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment	Flood: Plain: Mgt.	Structural Measures: Projects	Multi-purpose Dams	Storage: Total	Flood Prev.	Channel Impr.	Cost: Structural Measures: One Time: Total	Flood Prev.	Avg.Ann.* Total	Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool
		1000 Ac.		No.	No.	1000 Ac.Ft.		Mi.	$ million					1000 Ac.
	1966	2		1	3	2	1	-						
NATIONAL EFFICIENCY														
	1980	18	1	1	2	37	8	-	4.5	1.1	.3	.1	20	1.2
	2000	-	-	-										
	2020	161	-	4	4	118	38	-	10.6	3.3	.6	.1	32	3.7
REGIONAL DEVELOPMENT														
	1980	18	1	1	2	37	8	-	4.5	1.1	.3	.1	20	1.2
	2000	-	-	-										
	2020	161	-	8	4	118	38	-	10.6	3.3	.6	.1	37	3.7
ENVIRONMENTAL QUALITY														
	1980	414	2	-										
	2000	827	82	-										
	2020	827	27	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION A - AREA 3

Floods of 100 year frequency magnitude inundate about 43,706 acres. Land use in this flood plain consists of 5,372 acres of cropland and pasture, 26,927 acres of forest, 3,203 acres of built-up, and 8,204 acres of miscellaneous lands.

Floods presently cause an estimated $294,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $417,000 in 1980; $666,000 in 2000; and $1,224,000 in 2020.

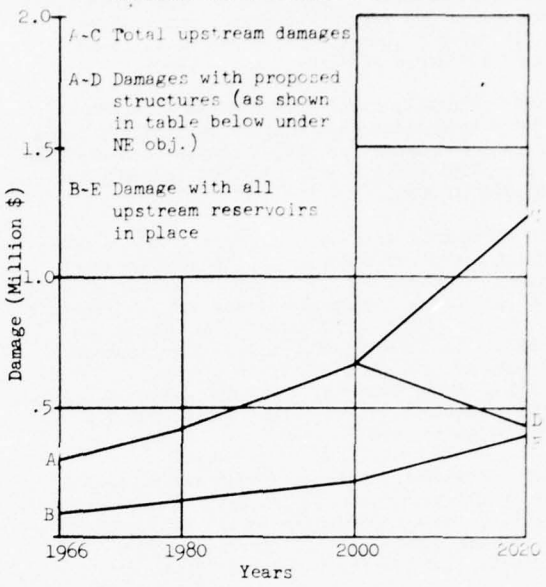
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 3,575,000 acres of land in Area 3, 659,000 acres require treatment and are feasible to treat. A net 321,000 acres will change use by 2020. Land use (1966) in the 31 watersheds consists of 287,000 acres of cropland, 70,000 acres of pasture, 3,099,000 acres of forest, 96,000 acres of urban, and 23,000 acres of other land.

Fully utilized, 62 potential upstream reservoir sites would have 862,500 acre feet of storage at an average cost of $60/acre foot. Allotment of the storage capacity is 30% for sediment and floodwater and 70% for other beneficial uses.

The release of 892 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 577 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
31,800 acres in 29 pools over 500 acres in size
7,030 acres in 21 pools 200-500 acres in size
760 acres in 5 pools 100-200 acres in size
120 acres in 2 pools less than 100 acres in size.
Average depths are 14 feet, 20 feet, 27 feet and 16 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 29 small watersheds in Area 3, 8 appear to warrant structural measures with flood prevention as a primary use. The 31 reservoirs with 118,500 acre feet of temporary storage could reduce flood damage by 67%. These 8 upstream watersheds deserve further study for early action projects. Another 121,200 acre feet of temporary storage in 31 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 1.2% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 24,000 acres in the 10 year and 38,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment (1000 Ac.)	Flood: Plain: Mgt. (1000 Ac.)	Structural Measures: Projects (No.)	Multi-purpose Dams (No.)	Storage: Total (1000 Ac.Ft.)	Storage: Flood Prev. (1000 Ac.Ft.)	Storage: Channel Impr. (Mi.)	Cost: Structural Measures: One Time Total ($ million)	Cost: Structural Measures: One Time Flood Prev. ($ million)	Cost: Structural Measures: Avg.Ann.* Total ($ million)	Cost: Structural Measures: Avg.Ann.* Flood Prev. ($ million)	Benefits: Str.Measures: % Damage Reduction	Benefits: Str.Measures: Area Perm. Pool (1000 Ac.)
	1966			-										
NATIONAL EFFICIENCY														
	1980	-	4	-										
	2000	-	3	-										
	2020	167	-	8	31	356	126	-	22.5	8.2	1.1	.4	67	16.-
REGIONAL DEVELOPMENT														
	1980	-	4	-										
	2000	-	3	-										
	2020	167	-	8	31	356	126	-	22.5	8.2	1.1	.4	67	16.-
ENVIRONMENTAL QUALITY														
	1980	132	6	-										
	2000	264	30	-										
	2020	263	8	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION A - AREA 4

Floods of 100 year frequency magnitude inundate about 25,731 acres. Land use in this flood plain consists of 4,281 acres of cropland and pasture, 15,556 acres of forest, 605 acres of built-up, and 5,289 acres of miscellaneous lands.

Floods presently cause an estimated $233,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $349,000 in 1980; $633,000 in 2000; and $1,292,000 in 2020.

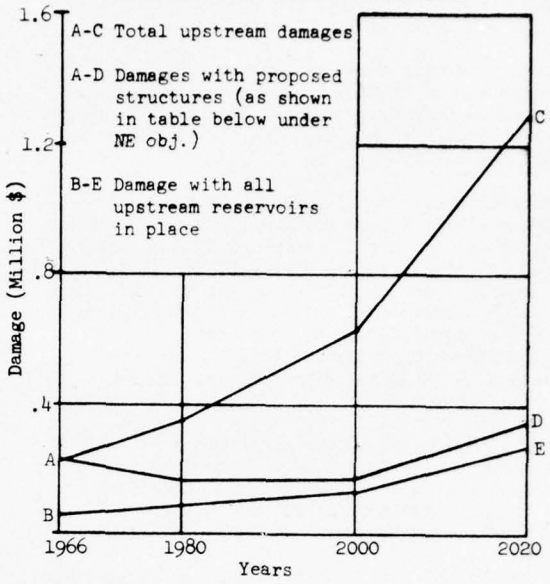
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 2,113,000 acres of land in Area 4, 1,316,000 acres require treatment and are feasible to treat. A net 131,000 acres will change use by 2020. Land use (1966) in the 30 watersheds consists of 132,000 acres of cropland, 26,000 acres of pasture, 1,833,000 acres of forest, 86,000 acres of urban, and 36,000 acres of other land.

Fully utilized, 63 potential upstream reservoir sites would have 850,300 acre feet of storage at an average cost of $70/acre foot. Allotment of the storage capacity is 27% for sediment and floodwater and 73% for other beneficial uses.

The release of 916 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 593 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
19,020 acres in 20 pools over 500 acres in size
8,100 acres in 23 pools 200-500 acres in size
1,380 acres in 10 pools 100-200 acres in size
240 acres in 5 pools less than 100 acres in size.
Average depths are 19 feet, 30 feet, 30 feet and 54 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 29 small watersheds in Area 4, 2 appear to warrant structural measures with flood prevention as a primary use. The 10 reservoirs with 34,200 acre feet of temporary storage could reduce flood damage by 73%. These 2 upstream watersheds deserve further study for early action projects. Another 174,500 acre feet of temporary storage in 53 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 1.2% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 14,000 acres in the 10 year and 22,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment 1000 Ac.	Flood Plain Mgt.	Structural Measures: Projects No.	Multi-purpose Dams No.	Storage: Total 1000 Ac.Ft.	Storage: Flood Prev.	Storage: Channel Impr. Mi.	Cost: Structural Measures: One Time: Total $ million	One Time: Flood Prev.	Avg.Ann.*: Total	Avg.Ann.*: Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool 1000 Ac.
	1966			2	5	44	15	.5						
NATIONAL EFFICIENCY														
	1980	34	-	1	4	22	12	-	4.1	3.3	.1	.1	55	.4
	2000	132	-	1	6	76	26	-	3.8	2.1	.1	.1	18	3.3
	2020	-	-	1	-									
REGIONAL DEVELOPMENT														
	1980	34	-	1	4	22	12	-	4.1	3.3	.1	.1	55	.4
	2000	132	-	1	6	76	26	-	3.8	2.1	.1	.1	18	3.3
	2020	-	-	1	-									
ENVIRONMENTAL QUALITY														
	1980	263	-	3	-									
	2000	526	-	18	-									
	2020	526	-	5	-									

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION A - AREA 5

Floods of 100 year frequency magnitude inundate about 167,290 acres. Land use in this flood plain consists of 445 acres of cropland and pasture, 103,735 acres of forest, 442 acres of built-up, and 62,668 acres of miscellaneous lands.

Floods presently cause an estimated $147,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $184,000 in 1980; $366,000 in 2000; and $733,000 in 2020.

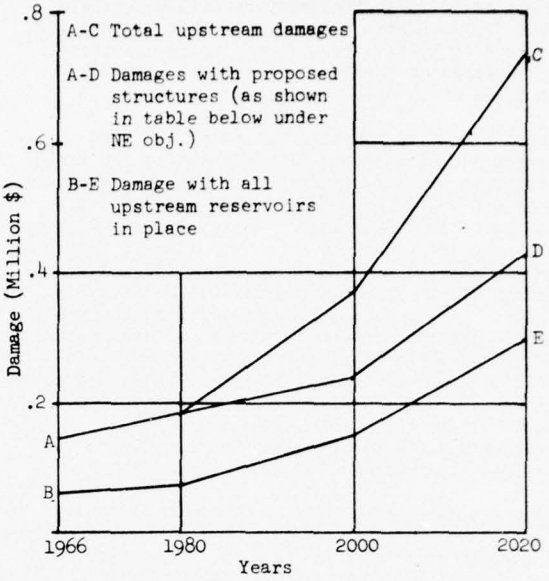
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 346,500 acres of land in Area 5, 1,695,000 acres require treatment and are feasible to treat. A net 192,000 acres will change use by 2020. Land use (1966) in the 43 watersheds consists of 215,000 acres of cropland, 15,000 acres of pasture, 2,974,000 acres of forest, 126,000 acres of urban, and 135,000 acres of other land.

Fully utilized, 81 potential upstream reservoir sites would have 1,202,500 acre feet of storage at an average cost of $42/acre foot. Allotment of the storage capacity is 27% for sediment and floodwater and 73% for other beneficial uses.

The release of 1,769 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 1,144 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
70,690 acres in 44 pools over 500 acres in size
8,620 acres in 26 pools 200-500 acres in size
540 acres in 4 pools 100-200 acres in size
Average depths are 10 feet, 23 feet, 14 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 43 small watersheds in Area 5, 8 appear to warrant structural measures with flood prevention as a primary use. The 16 reservoirs with 64,500 acre feet of temporary storage could reduce flood damage by 43%. These 8 upstream watersheds deserve further study for early action projects. Another 232,300 acre feet of temporary storage in 65 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 4.8% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 95,000 acres in the 10 year and 142,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment	Flood Plain Mgt.	Structural Measures: Projects	Multi-purpose Dams	Storage: Total	Flood Prev.	Channel Impr.	Cost: Structural Measures: One Time Total	One Time Flood Prev.	Avg.Ann.* Total	Avg.Ann.* Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool
		1000 Ac.		No.	No.	1000 Ac.Ft.		Mi.	$ million					1000 Ac.
	1966			-										
NATIONAL EFFICIENCY														
	1980	-	1	-										
	2000	147	-	4	10	194	58	-	6.9	2.1	.3	.1	34	16.1
	2020	44	-	4	6	46	12	-	2.5	.7	.1	.1	8	2.7
REGIONAL DEVELOPMENT														
	1980	-	1	-										
	2000	191	-	8	16	240	70	-	9.4	2.8	.4	.1	42	18.8
	2020	26	-	1	2	28	7	-	1.2	.3	.1	.1	1	1.7
ENVIRONMENTAL QUALITY														
	1980	339	1	-										
	2000	678	104	-										
	2020	678	62	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

UPSTREAM FLOOD DAMAGES, WATER MANAGEMENT AN
SUBREGION A

Subarea Project Classification	General Watershed Data: Number of Projects	Water-shed Area sq.mi.	Pertinent Flood Plain Information: Area Inundated by 100 Year Freq. Flood: Crop & Pasture ac.	Wood-lands ac.	Other: Urban ac.	Other: Misc. ac.	Total ac.	Average Annual Flood Damage: Crop	Other: Agr.	Resid. & Indus.	Comm.	Trans.	Other:	Total	Benefit: Flood Prev.: Damage Redctn	Agr.: Rec MIU&: Water CIU : Mgt.	
AREA 1 ST. JOHN RIVER																	
1a 3/	4	187	115	2515	75	580	3285	.5	7.5	2.4	9.6	3.6	6.7	30.3	28.8		
1b 3/	14	1995	285	20580	595	4760	26220	4.6	3.5	31.5	48.8	31.6	13.1	133.1	114.5		
Not Evaluated	4	5177															
Authorized P.L. 566	4	346	100	990	355	390	1835	.6	10.3	21.5	44.5	18.4	14.2	109.5	101.4	49.4	- 138.
Potential Flood Prev. Projects	3	258	140	2830	195	895	4060	3.5	.6	6.4	8.2	12.8	5.0	36.5	30.7		
Potential Developments	11	1578	160	19275	120	4055	23610	1.0	.1	6.0	5.7	4.0	.6	17.4	11.2		
TOTAL 3/	18	2182	400	23095	670	5340	29505	5.1	11.0	33.9	58.4	35.2	19.8	163.4	143.3		
AREA 2 PENOBSCOT RIVER																	
Not Evaluated	5	4664															
Authorized P.L. 566	1	8	-	95	50	55	200	-	4.6	4.2	12.4	7.4	.6	29.2	27.1	1.8	- 2.
Potential Flood Prev. Projects	5	682	626	7725	294	4435	13080	.7	6.3	23.8	40.4	15.2	1.7	88.1	58.7		
Potential Developments	30	3171	327	73994	202	22908	97431	.3	.1	8.5	9.5	5.0	-	23.4	13.2		
TOTAL 3/	36	3861	953	81814	546	27398	110711	1.0	11.0	36.5	62.3	27.6	2.3	140.7	99.0		
AREA 3 KENNEBEC RIVER																	
Not Evaluated	2	2894															
Authorized P.L. 566	0																
Potential Flood Prev. Projects	8	1415	5173	13081	3068	4931	26253	92.3	13.9	66.6	61.5	31.1	2.5	267.9	196.5		
Potential Developments	21	1562	199	13846	135	3273	17453	-	1.0	12.0	-	12.3	.3	25.6	3.6		
TOTAL 3/	29	2977	5372	26927	3203	8204	43706	92.3	14.9	78.6	61.5	43.4	2.8	293.5	200.1		
AREA 4 ANDROSCOGGIN RIV																	
4a 3/	7	1404	790	4766	50	1912	7518	4.5	-	4.5	14.1	4.2	2.4	29.6	23.7		
4b 3/	22	1557	3491	10790	555	3377	18213	3.3	2.1	101.0	46.9	63.6	23.0	239.9	199.6		
Not Evaluated	1	485															
Authorized P.L. 566	2	195	1200	2000	30	110	3340	.4	-	20.2	8.1	2.5	7.4	38.6	36.8	22.0	- 135.
Potential Flood Prev. Projects	2	415	1950	1026	477	734	4187	2.5	-	80.7	44.6	52.2	17.6	197.6	170.3		
Potential Developments	25	2351	1131	12530	98	4445	18204	4.9	2.1	4.6	8.3	13.1	.4	33.3	16.2		
TOTAL 3/	29	2961	4281	15556	605	5289	25731	7.8	2.1	105.5	61.0	67.8	25.4	269.5	223.3		
AREA 5 ST. CROIX RIVER AND COAS																	
5a 3/	5	584	9	8439	35	1259	9742	-	-	5.4	-	2.9	-	8.3	5.0		
5b 3/	38	2972	436	95296	407	61409	157557	1.1	-	33.4	46.9	47.8	9.6	138.8	82.6		
Not Evaluated	3	2673															
Authorized P.L. 566	0																
Potential Flood Prev. Projects	8	608	24	21023	178	13437	34662	-	-	28.2	36.4	10.0	8.9	83.5	63.3		
Potential Developments	35	2948	421	82712	264	49231	132628	1.1	-	10.6	10.5	40.7	.7	63.6	24.3		
TOTAL 3/	43	3556	445	103735	442	62668	167290	1.1	-	38.8	46.9	50.7	9.6	147.1	87.6		
SUBREGION A																	
Not Evaluated	15	15893															
Authorized P.L. 566	7	549	1300	3085	435	555	5375	1	15	46	65	28	22	177	165	73	- 277
Potential Flood Prev. Projects	26	3378	7913	45685	4212	24432	82242	99	21	206	191	121	36	674	520		
Potential Developments	122	11610	2238	202357	819	83912	289326	7	3	42	34	75	2	163	68		
TOTAL 3/	155	15537	11451	251127	5466	108899	376943	107	39	294	290	224	60	1014	753		

1/ To crest of emergency spillway.
2/ Storage for beneficial uses other than flood prevention.
3/ Excludes Not Evaluated.
4/ Additional storage is available. The limit of the study is 25,000 acre feet per dam.
5/ Channel improvement in miles.
6/ Includes redevelopment and/or secondary benefits.
Note: Inventory base 1966; Price base 1970; Ammortization rate, 5-1/8% over 100 years.

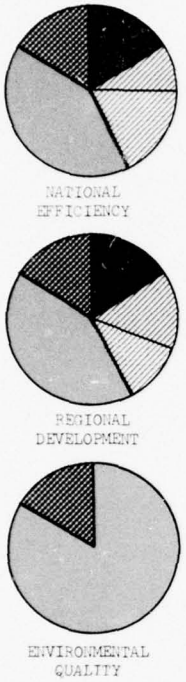
WATER MANAGEMENT AND STRUCTURAL MEASURES
SUBREGION A

Flood Damage Trans.	Other	Total	Benefits: Flood Prev. Damage Redctn	Agr. Water: MIU& CLW	Rec. Other Uses	Total	Costs: Flood Prev.	Agr. Water Mgt.	Rec.	Other Uses	Total Avrg. Annl.	Total Est. Cost	No. of Dams	D.A. above Dams sq.mi.	Sedi-ment	Flood-water 1/	Storage: Other Uses 2/ Alloc.	Avail.	Total	Area Perm. Pool ac.	Other Water-shed Imp. 3/
dollars			thousand dollars				thousand dollars										thousand acre feet				
AREA 1 ST. JOHN RIVER																					
3.6	6.7	30.3	28.8			121.8					281.7	8080	10	153.3	2.4	25.2	.9	80.6	109.1 4/	2752	
31.6	13.1	133.1	114.5			428.3					1378.2	24468	38	602.4	9.4	108.6	12.2	235.3	365.5 4/	14838	.8
18.4	14.2	109.5	101.4	49.4	- 138.9	38.9 387.5 6/	115.9	- 79.9	20.6		216.4	5027	15	201.7	1.6	31.0	13.1	14.6	60.3	1527	.8
12.8	5.0	36.5	30.7				147.6				317.9	6026	10	131.4	1.5	22.4	-	50.5	74.4	2670	
4.0	.6	17.4	11.2				286.6				1125.6	21495	23	422.6	8.7	80.4	-	250.8	339.9	13393	
35.2	19.8	163.4	143.3				550.1				1669.9	32548	48	755.7	11.8	133.8	13.1	315.9	474.6	17590	.8
AREA 2 PENOBSCOT RIVER																					
7.4	.6	29.2	27.1	1.8	- 2.0	2.6 33.5	16.8	- 1.9	-		18.7	457	3	6.2	.1	.9	1.0	-	2.0	10	
15.2	1.7	88.1	58.7				228.4				766.8	15040	10	223.8	3.8	42.3	2.1	107.4	155.6	4905	
5.0	-	23.4	13.2				523.7				2043.5	39190	41	957.9	15.5	169.5	2.9	518.5	706.4	38830	
27.6	2.3	140.7	99.0				768.9				2829.0	54687	54	1187.9	19.4	212.7	6.0	625.9	864.0	43765	
AREA 3 KENNEBEC RIVER																					
31.1	2.5	267.9	196.5				465.6				1192.6	22474	31	639.1	7.3	118.5	8.9	221.3	356.0	16388	1.0
12.3	.3	25.6	3.6				432.4				1572.8	29621	31	614.7	9.9	121.2	-	375.4	506.5	23329	
43.4	2.8	293.5	200.1				898.0				2765.4	52095	62	1253.8	17.2	239.7	8.9	596.7	862.5	39717	1.0
AREA 4 ANDROSCOGGIN RIVER																					
4.2	2.4	29.6	23.7				356.7				1586.7	30212	31	503.5	9.0	88.8	1.3	371.2	470.3	17822	.5
63.6	23.0	239.9	199.6				606.3				1686.8	32614	37	610.1	11.1	134.3	28.3	250.7	424.4	13057	
2.5	7.4	38.6	36.8	22.0	- 135.7	- 222.7	55.4	- 68.7	-		124.1	3285	5	56.4	.4	14.4	29.6	-	44.4	2140	.5
52.2	17.6	197.6	170.3				191.1				415.3	7862	10	186.0	3.0	34.2	-	59.8	97.0	3687	
13.1	.4	33.3	16.2				716.5				2734.1	51679	53	871.2	16.7	174.5	-	562.1	753.3	25052	
67.8	25.4	269.5	223.3				963.0				3273.5	62826	68	1113.6	20.1	223.1	29.6	621.9	894.7	30879	.5
ST. CROIX RIVER AND COASTAL AREA																					
2.9	-	8.3	5.0				40.5				202.8	3803	7	58.7	1.5	11.2	-	46.8	62.5	5195	
47.8	9.6	138.8	82.6				660.9				2511.6	46709	74	1494.7	23.9	285.6	2.0	828.5	1140.0	74655	
10.0	8.9	83.5	63.3				110.4				424.5	9434	16	337.8	5.3	64.5	2.0	167.8	239.6	18800	
40.7	.7	63.6	24.3				591.0				2289.9	41078	65	1215.2	20.1	232.3	-	710.5	962.9	61050	
50.7	9.6	147.1	87.6				701.4				2714.4	50512	81	1553.0	25.4	296.8	2.0	878.3	1202.5	79850	
SUBREGION A																					
28	22	177	165	73	- 277	42 644	188	- 151	21		360	8769	23	264	2	46	44	15	107	3677	1.3
121	36	674	520				1143				3117	60836	77	1518	21	282	13	607	923	46470	1.0
75	2	163	68				2550				9766	183063	213	4082	71	778	3	2417	3269	161654	
224	60	1014	753				3881				13243	252668	313	5864	94	1106	60	3039	4299	211801	2.3

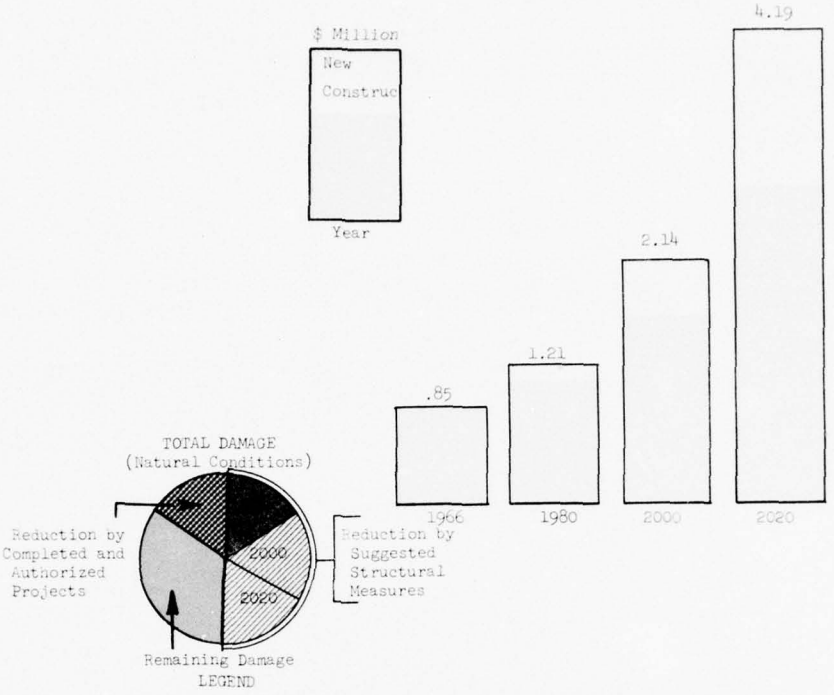
SUBREGION A
TABLE F-4

FLOOD DAMAGE DISTRIBUTION AND PROJECTIONS

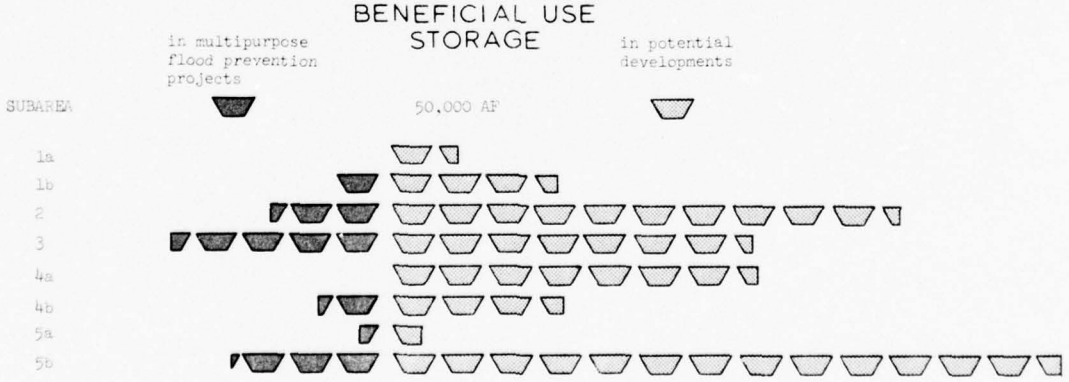
DISTRIBUTION

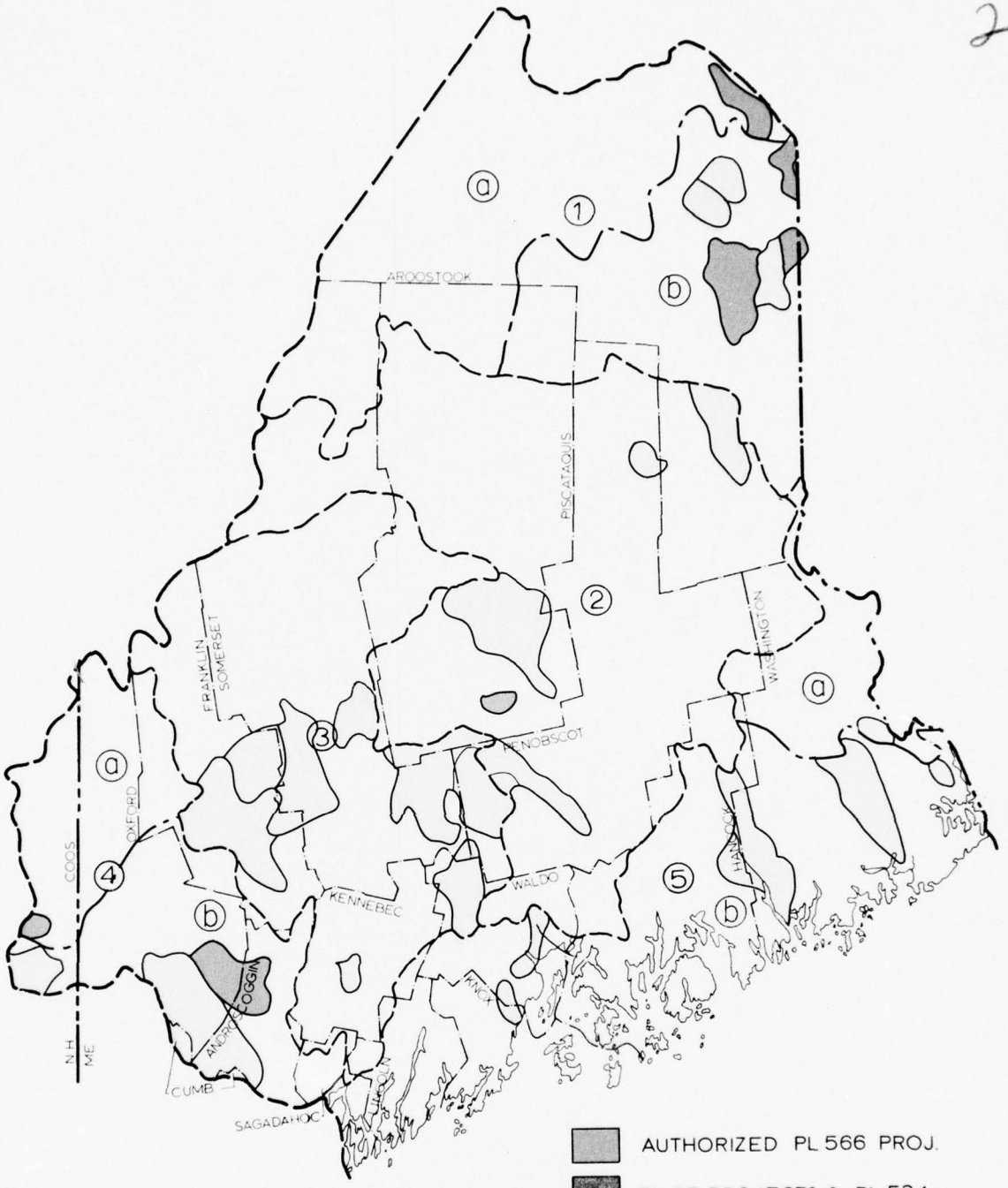


PRESENT AND PROJECTED AVERAGE ANNUAL DAMAGES



POTENTIAL WATER SUPPLY FROM UPSTREAM RESERVOIRS





SUB-REGION A
AREAS ① - ⑤

UPSTREAM FLOOD PREVENTION PROJECTS

10 0 10 20 30 40 Miles
SCALE

FIGURE F-19

USDA-SCS-HYATTSVILLE, MD. 1971

SUBREGION B (Areas 6, 7, 8, 9 and 10)

Flooding

Area Inundated. Total area inundated by the 100 year frequency flood in the Subregion is approximately 472,000 acres (Table F-5). Of this 24 percent is in crop and pasture, 14 percent is in forest land, and 62 percent is in urban and miscellaneous. This contrasts with Subregion A where woodland was the predominant area inundated.

Area 9 has the greatest and Area 10 has the least total area inundated. The greatest and the least acreage inundated in crop and pasture is in Areas 8 and 6 respectively. The greatest and least acreage inundated in forest land is in Areas 6 and 9 respectively. The greatest and least acreage inundated in urban and miscellaneous is in Areas 9 and 10 respectively.

Area inundated as a percent of total area for the Subregion is 3. It ranged from 1 percent in Area 8 to 7 percent in Area 9.

Present Damages. The present average annual damage in the Subregion is approximately $18.0 million. It ranged from $1.3 million in Area 6 to $6.0 million in Area 9. Of the total, 6 percent is agricultural, and 94 percent is nonagricultural. The percent agricultural damage ranged from 1 percent in Area 10 to 16 percent in Area 6.

The present average annual damage in dollars per acre of area inundated ranged from $20 in Area 6 to $94 in Area 10. Area 10 has the highest damageable value per acre inundated in the Region. The average for the Subregion is $43 which is also the highest in the Region.

There are 23 authorized PL 566 projects and one Pilot Watershed in upstream areas which will reduce present average annual damage by $2.49 million, leaving a damage of $1.99 million. Present average annual damage in the remaining upstream areas is $16.03 million.

Future Damage. If no additional flood prevention measures were installed, the present average annual flood damages of $18.0 million would increase to $27.9 million in 1980, $52.8 million in 2000, and $106.8 million in 2020 (Figure F-20). The range in annual damage in 2020 would be $7.6 million in Area 6 to $34.0 million in Area 9.

Extent and Timing of Flood Prevention Measures

Structural Measures. Suggested flood prevention structural measures involving installation of 380 multiple purpose dams with 603,900 acre feet of flood prevention storage at an average annual cost of $7.05 million will reduce annual flood damage by $35.53

million in 2020. The tables on pages F-54 through F-58 indicate the extent and timing of potential flood prevention structural measures for each objective by Area. The installation of structures involving National Forest land will depend upon further analysis to determine compatibility with National Forest purposes.

Flood Plain Management. Flood prevention plans for the 472,000 acre flood plain should include nonstructural measures or devices as alternatives, in combination, and/or in addition to structural measures. With all potential flood prevention structural measures installed the annual damages remaining would be $18.8 million, $35.5 million, $71.1 million in 1980, 2000 and 2020 respectively (Figure F-20). Flood plain management of the 100,000 acres subject to high damages, would reduce this remaining damage.

Water Management

In the 24 authorized PL 566 projects there are included 21,700 acre feet of storage for uses other than flood prevention in multiple purpose reservoirs. As of 1967 under the CO program of the USDA technical assistance was provided for the installation of about 300 miles of diversions, 500 miles of tile, and 1300 miles of open main ditches for drainage and flood prevention. Also installed were about 12,600 ponds for flood prevention, irrigation, recreation, fish and wildlife, livestock, rural domestic, and fire protection.

In addition to flood prevention storage in the Potential Flood Prevention Projects, there is storage of 1.31 million acre feet for other uses. There are about 1.65 million acre feet of storage for other uses in the Potential Developments. The total available for water management in potential upstream impoundments is 2.96 million acre feet. The specific needs for water will be identified in other appendices.

Programs and Activities

PL 566. As of 1967 there were 24 authorized PL 566 projects in the Subregion; two are in Area 6, five in Area 7, and 11 in Area 8, one in Area 9, and five in Area 10. Flood prevention storage of 112,000 acre feet and 21,700 acre feet of storage for other uses are included in 103 dams. The total estimated cost is $50.2 million.

RC&D. There are four RC&D's in the Subregion. A portion of the East Central Vermont RC&D project is located in Area 8. It was the desire of the sponsors that the land, water, plant and wildlife resources be fully developed, conserved and used for the benefit of people.

A portion of the North Country RC&D project is located in Area 6, 7, and 8. The objective of this project is to provide technical

and financial assistance for the conservation and development of the water, land and related natural resources for the economic betterment of the area citizens.

Most of the Berkshire-Franklin RC&D project is in Areas 8 and 10. The project aim is to improve environmental quality; help to expand industry, commerce, and community services; and, publicize the attractiveness of the area.

A portion of the Eastern Connecticut RC&D project is in Area 8. The primary objective of the project is to speed up conservation and development of the area's natural resources.

Type II Coordinated Comprehensive Detailed Study. A Type II Study was recently completed for the Connecticut River Basin (Area 8).

Type IV Cooperative Survey. A statewide Massachusetts Water Resource Type IV Study was begun in 1969.

New England-New York Inter-Agency Committee Report. All of Subregion 8 is included in this report. The principal authorization for the survey was Section 205 of the Rivers and Harbors and Flood Control Act approved May 17, 1950. The principal subjects are discussions of the river basins, economic development, storage and stream flow regulation, water supply, pollution control, flood control and drainage, power development, navigation and beach erosion, fish and wildlife, recreation, management of agricultural and forest lands, minerals, and insect control.

SUBREGION B - AREA 6

Floods of 100 year frequency magnitude inundate about 67,845 acres. Land use in this flood plain consists of 10,384 acres of cropland and pasture, 22,565 acres of forest, 6,466 acres of built-up, and 28,430 acres of miscellaneous lands.

Floods presently cause an estimated $1,320,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $2,059,000 in 1980; $3,748,000 in 2000; and $7,603,000 in 2020.

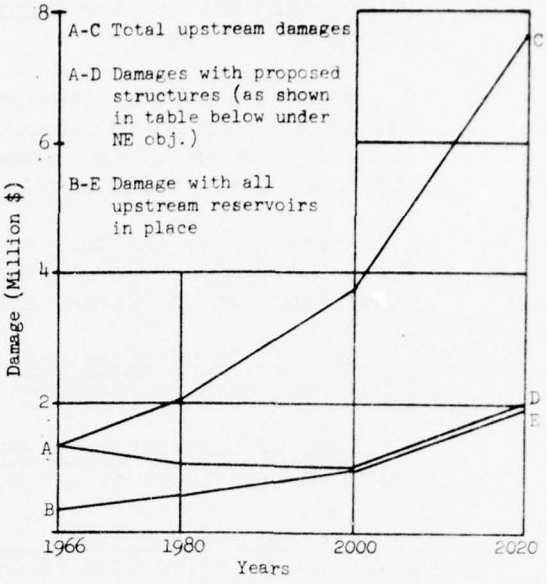
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 2,471,000 acres of land in Area 6, 1,550,000 acres require treatment and are feasible to treat. A net 228,000 acres will change use by 2020. Land use (1966) in the 38 watersheds consists of 170,000 acres of cropland, 34,000 acres of pasture, 197,000 acres of forest, 142,000 acres of urban, and 155,000 acres of other land.

Fully utilized, 121 potential upstream reservoir sites would have 994,200 acre feet of storage at an average cost of $94/acre foot. Allotment of the storage capacity is 29% for sediment and floodwater and 71% for other beneficial uses.

The release of 1,411 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 911 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
22,910 acres in 25 pools over 500 acres in size
13,760 acres in 43 pools 200-500 acres in size
3,260 acres in 20 pools 100-200 acres in size
1,080 acres in 17 pools less than 100 acres in size.
Average depths are 14 feet, 21 feet, 21 feet and 17 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 38 small watersheds in Area 6, 14 appear to warrant structural measures with flood prevention as a primary use. The 92 reservoirs with 183,300 acre feet of temporary storage could reduce flood damage by 74%. These upstream watersheds deserve further study for early action projects. Another 84,400 acre feet of temporary storage in 29 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 2.7% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 45,000 acres in the 10 year and 60,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment (1000 Ac.)	Flood: Plain: Mgt.	Structural Measures: Projects (No.)	Multi-purpose Dams (No.)	Storage: Total (1000 Ac.Ft.)	Flood Prev.	Channel Impr. (Mi.)	Cost: Structural Measures: One Time ($ million)	Avg.Ann.*	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool (1000 Ac.)
	1966			2	7	10	9	-				
NATIONAL EFFICIENCY												
	1980	355	5	5	39	314	91	-	47.4	13.3	50	9.5
	2000	543	-	9	53	391	110	-	30.0	7.5	24	18.1
	2020	-	5	-								
REGIONAL DEVELOPMENT												
	1980	355	5	5	39	314	91	-	47.4	13.3	50	9.5
	2000	543	-	9	53	391	110	-	30.0	7.5	24	18.1
	2020	-	5	-								
ENVIRONMENTAL QUALITY												
	1980	310	12	-								
	2000	620	28	-								
	2020	620	28	-								

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

Floods of 100 year frequency magnitude inundate about 91,755 acres. Land use in this flood plain consists of 19,755 acres of cropland and pasture, 9,892 acres of forest, 7,288 acres of built-up, and 54,820 acres of miscellaneous lands.

Floods presently cause an estimated $2,386,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $3,675,000 in 1980; $6,992,000 in 2020; and $14,152,000 in 2020.

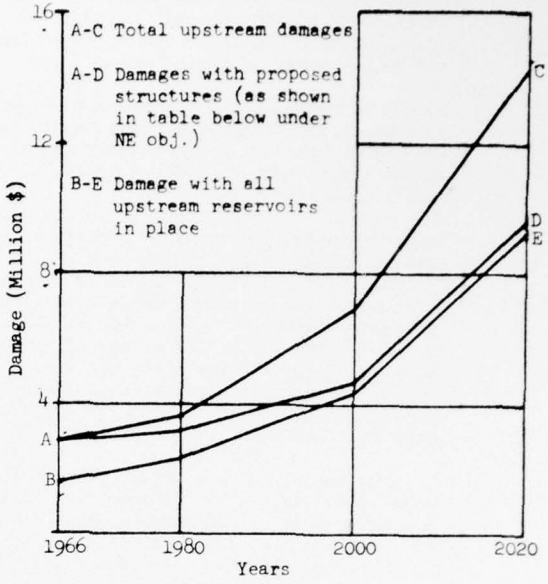
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 3,076,000 acres of land in Area 7, 1,853,000 acres require treatment and are feasible to treat. A net 537,000 acres will change use by 2020. Land use (1966) in the 46 watersheds consists of 168,000 acres of cropland, 57,000 acres of pasture, 2,390,000 acres of forest, 273,000 acres of urban, and 188,000 acres of other land.

Fully utilized, 174 potential upstream reservoir sites would have 857,100 acre feet of storage at an average cost of $145/acre foot. Allotment of the storage capacity is 26% for sediment and floodwater and 74% for other beneficial uses.

The release of 1,543 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 997 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
15,390 acres in 14 pools over 500 acres in size
22,090 acres in 67 pools 200-500 acres in size
11,520 acres in 77 pools 100-200 acres in size
3,810 acres in 63 pools less than 100 acres in size.
Average depths are 8 feet, 15 feet, 20 feet and 19 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 40 small watersheds in Area 7, 16 appear to warrant structural measures with flood prevention as a primary use. The 99 reservoirs with 112,600 acre feet of temporary storage could reduce flood damage by 32. These 16 upstream watersheds deserve further study for early action projects. Another 86,900 acre feet of temporary storage in 75 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 30% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 61,000 acres in the 10 year and 82,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment (1000 Ac.)	Flood: Plain: Mgt.	Structural Measures: Projects No.	Multi-purpose Dams No.	Storage: Total (1000 Ac.Ft.)	Flood Prev. (1000 Ac.Ft.)	Channel Impr. (Mi.)	Cost: Structural Measures: One Time: Total ($ million)	One Time: Flood Prev.	Avg.Ann.*: Total	Avg.Ann.*: Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool (1000 Ac.)
	1966			5	53	179	46	1						
NATIONAL EFFICIENCY														
	1980	187	10	5	31	165	40	-	22.6	5.5	1.2	.3	11	6.4
	2000	495	5	11	68	358	85	-	53.4	12.9	2.9	.7	21	16.6
	2020	-	15	-										
REGIONAL DEVELOPMENT														
	1980	556	9	11	83	446	104	-	54.3	13.1	2.9	.7	22	18.1
	2000	116	6	5	16	77	21	-	21.7	5.4	1.2	.3	10	4.9
	2020	-	15	-										
ENVIRONMENTAL QUALITY														
	1980	370	17	-										
	2000	741	20	-										
	2020	741	55	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

Floods of 100 year frequency magnitude inundate about 79,929 acres. Land use in this flood plain consists of 36,193 acres of cropland and pasture, 13,010 acres of forest, 4,617 acres of built-up, and 26,109 acres of miscellaneous lands.

Floods presently cause an estimated $4,050,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $6,237,000 in 1980; $12,028,000 in 2000; and $24,812,000 in 2020.

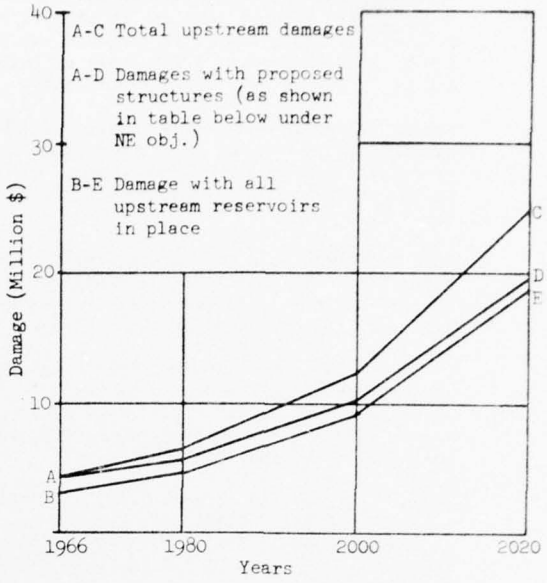
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 6,958,000 acres of land in Area 8, 3,013,000 acres require treatment and are feasible to treat. A net 1,078,000 acres will change use by 2020. Land use (1966) in the 137 watersheds consists of 598,000 acres of cropland, 341,000 acres of pasture, 5,489,000 acres of forest, 258,000 acres of urban, and 272,000 acres of other land.

Fully utilized, 338 potential upstream reservoir sites would have 1,752,100 acre feet of storage at an average cost of $180/acre foot. Allotment of the storage capacity is 32% for sediment and floodwater and 68% for other beneficial uses.

The release of 2,449 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 1,582 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
11,130 acres in 17 pools over 500 acres in size
25,930 acres in 84 pools 200-500 acres in size
19,297 acres in 133 pools 100-200 acres in size
5,218 acres in 87 pools less than 100 acres in size.
Average depths are 23 feet, 21 feet, 20 feet and 19 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 128 small watersheds in Area 8, 13 appear to warrant structural measures with flood prevention as a primary use. The 63 reservoirs with 99,000 acre feet of temporary storage could reduce flood damage by 19%. These 13 upstream watersheds deserve further study for early action projects. Another 412,300 acre feet of temporary storage in 275 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 1.1% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 50,000 acres in the 10 year and 69,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment 1000 Ac.	Flood Plain Mgt.	Structural Measures: Projects Multi-purpose Dams No.	Storage Total 1000 Ac.Ft.	Storage Flood Prev.	Storage Chan-nel Impr. Mi.	Cost: Structural Measures: One Time Total $ million	One Time Flood Prev.	Avg.Ann.* Total	Avg.Ann.* Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool 1000 Ac.
	1966			11	34	36	34	24					
NATIONAL EFFICIENCY													
	1980	272	6	5	22	140	52	-	22.1	14.2	1.4	.9	9	2.9
	2000	155	6	5	29	89	38	.5	20.4	6.8	1.2	.4	7	3.2
	2020	31	10	3	12	23	13	-	6.8	5.1	.4	.3	5	.5
REGIONAL DEVELOPMENT													
	1980	297	6	6	24	149	59	-	24.6	13.8	1.6	.9	10	2.9
	2000	162	5	7	39	102	45	-	24.7	10.6	1.4	.6	11	3.6
	2020	252	11	11	29	159	47	-	28.2	8.1	1.4	.4	1	5.7
ENVIRONMENTAL QUALITY													
	1980	603	23	-									
	2000	1205	31	-									
	2020	1205	26	-									

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION B - AREA 9

Floods of 100 year frequency magnitude inundate about 179,120 acres. Land use in this flood plain consists of 28,635 acres of cropland and pasture, 7,000 acres of forest, 19,780 acres of built-up, and 123,705 acres of miscellaneous lands.

Floods presently cause an estimated $6,040,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $9,242,000 in 1980; $17,215,000 in 2000; and $34,006,000 in 2020.

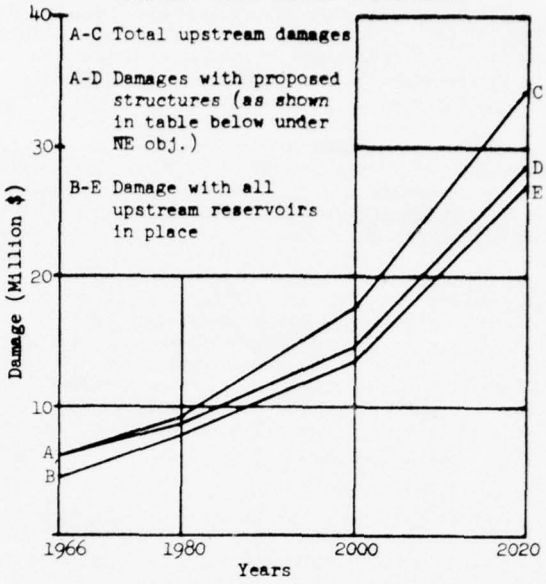
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 2,618,000 acres of land in Area 9, 966,000 acres require treatment and are feasible to treat. A net 956,000 acres will change use by 2020. Land use (1966) in the 80 watersheds consists of 145,000 acres of cropland, 59,000 acres of pasture, 1,616,000 acres of forest, 518,000 acres of urban, and 280,000 acres of other land.

Fully utilized, 85 potential upstream reservoir sites would have 327,300 acre feet of storage at an average cost of $227/acre foot. Allotment of the storage capacity is 35% for sediment and floodwater and 65% for other beneficial uses.

The release of 442 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 285 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
11,130 acres in 13 pools over 500 acres in size
11,440 acres in 35 pools 200-500 acres in size
2,740 acres in 19 pools 100-200 acres in size
630 acres in 11 pools less than 100 acres in size.
Average depths are 7 feet, 8 feet, 11 feet and 19 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 73 small watersheds in Area 9, 32 appear to warrant structural measures with flood prevention as a primary use. The 63 reservoirs with 63,800 acre feet of temporary storage could reduce flood damage by 19%. These 32 upstream watersheds deserve further study for early action projects. Another 41,700 acre feet of temporary storage in 22 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 6.8% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 134,000 acres in the 10 year and 163,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment (1000 Ac.)	Flood Plain Mgt.	Structural Measures: Projects (No.)	Multi-purpose Dams (No.)	Storage: Total (1000 Ac.Ft.)	Storage: Flood Prevention	Storage: Channel Improvement (Mi.)	Cost: Structural Measures: One Time: Total ($ million)	Cost: Structural Measures: One Time: Flood Prevention	Cost: Structural Measures: Avg.Ann.*: Total	Cost: Structural Measures: Avg.Ann.*: Flood Prevention	Benefits: Str.Measures: % Damage Reduction	Benefits: Str.Measures: Area Perm. Pool 1000 Ac.
	1966			1	1	1	1	-						
NATIONAL EFFICIENCY														
	1980	163	28	12	25	84	30	-	16.7	7.2	.9	.4	7	6.4
	2000	230	15	20	38	117	41	-	38.1	13.3	2.0	.7	11	10.0
	2020	-	43	-										
REGIONAL DEVELOPMENT														
	1980	170	27	13	27	91	33	-	19.3	7.4	1.0	.4	7	6.7
	2000	224	16	19	36	110	38	-	35.5	13.1	1.9	.7	11	9.7
	2020	-	43	-										
ENVIRONMENTAL QUALITY														
	1980	194	34	-										
	2000	386	21	-										
	2020	386	124	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

Floods of 100 year frequency magnitude inundate about 53,597 acres. Land use in this flood plain consists of 17,854 acres of cropland and pasture, 15,475 acres of forest, 4,495 acres of built-up, and 15,773 acres of miscellaneous lands.

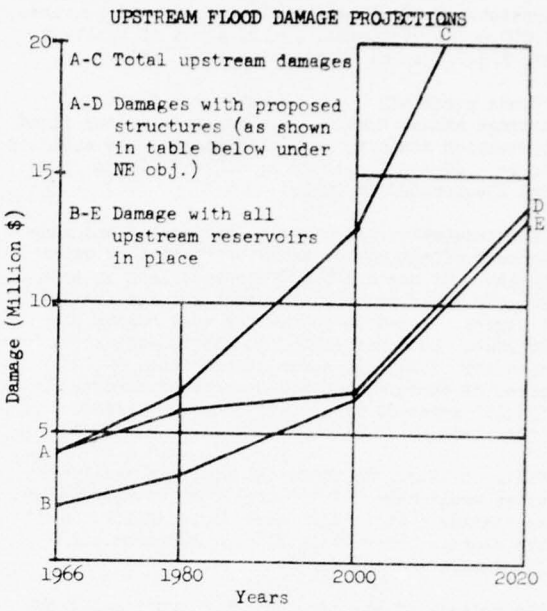
Floods presently cause an estimated $4,221,000 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $6,668,000 in 1980; $12,830,000 in 2000; and $26,505,000 in 2020.

Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 2,812,000 acres of land in Area 10, 1,216,000 acres require treatment and are feasible to treat. A net 730,000 acres will change use by 2020. Land use (1966) in the 90 watersheds consists of 237,000 acres of cropland, 159,000 acres of pasture, 1,922,000 acres of forest, 249,000 acres of urban, and 245,000 acres of other land.

Fully utilized, 96 potential upstream reservoir sites would have 376,900 acre feet of storage at an average cost of $269/acre foot. Allotment of the storage capacity is 44% for sediment and floodwater and 56% for other beneficial uses.

The release of 426 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 276 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
3,110 acres in 4 pools over 500 acres in size
6,600 acres in 22 pools 200-500 acres in size
3,880 acres in 25 pools 100-200 acres in size
1,070 acres in 17 pools less than 100 acres in size.
Average depths are 12 feet, 15 feet, 17 feet and 14 feet respectively.



Of the 88 small watersheds in Area 10, 27 appear to warrant structural measures with flood prevention as a primary use. The 63 reservoirs with 97,400 acre feet of temporary storage could reduce flood damage by 47%. These 27 upstream watersheds deserve further study for early action projects. Another 61,300 acre feet of temporary storage in 33 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 1.9% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 36,000 acres in the 10 year and 48,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment 1000 Ac.	Flood: Plain: Mgt.	Structural Measures: Projects No.	Multi-purpose Dams No.	Storage: Total 1000 Ac.Ft.	Flood Prev.	Chan-nel Impr. Mi.	Cost: Structural Measures: One Time: Total $ million	Flood Prev.	Avg.Ann.*: Total	Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool 1000 Ac.
	1966			5	20	21	19	3.5						
NATIONAL EFFICIENCY														
	1980	160	7	5	19	89	40	-	21.9	11.0	1.1	.6	9	2.4
	2000	254	-	22	44	143	63	-	49.2	28.0	2.7	1.6	39	6.0
	2020	-	8	-										
REGIONAL DEVELOPMENT														
	1980	300	4	16	38	147	69	-	53.9	31.2	2.9	1.7	38	4.7
	2000	113	3	11	25	86	34	-	17.1	8.5	.9	.4	9	3.9
	2020	-	7	6	4	16	7	-	3.2	1.5	.2	.1	1	.7
ENVIRONMENTAL QUALITY														
	1980	243	14	-										
	2000	486	24	-										
	2020	486	16	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

UPSTREAM FLOOD DAMAGES, WATER MANAGMEN
SUBREGION B

Subarea Project Classification	General Watershed Data: Number of Projects	Total Water-shed Area sq.mi.	Pertinent Flood Plain Information: Area Inundated by 100 Year Freq. Flood: Crop & Pas-ture ac.	Wood-lands ac.	Other: Urban ac.	Other: Misc. ac.	Total ac.	Average Annual Flood Damage: Crop	Other: Agr.	Resid. & Indus:	Comm.	Trans.	Other	Total	Bene: Flood Prev.: Agr.: Damage: MIU&: Water: Redctn: CIU : Mgt.: thousand dollars	thousand d
AREA 6 PRESUMPSCOT, SACO, PISCATAQU																
6a	15	695	700	7360	222	4329	12611	5.4	1.4	13.0	24.0	22.6	-	66.4	55.1	
6b	11	1552	8167	9633	4185	14247	36232	127.3	70.3	202.0	115.4	188.4	239.2	939.6	715.4	
6c	12	1351	1517	5572	2059	9854	19002	9.4	1.4	59.4	254.0	17.3	18.3	359.8	260.8	
Not Evaluated	4	595														
Authorized P.L. 566	2	116	1304	1192	70	350	2916	44.9	5.0	1.8	7.2	5.8	15.3	80.0	45.9	21.2 -
Potential Flood Prev. Projects	14	2223	8910	13847	6253	19339	48349	96.9	67.8	259.6	375.2	209.7	233.4	1242.6	978.4	
Potential Developments	22	1259	170	7526	143	8741	16580	.3	.3	13.0	11.0	9.8	8.8	43.2	7.0	
TOTAL 3/	38	3598	10384	22565	6466	28430	67845	142.1	73.1	274.4	393.4	225.3	257.5	1365.8	1031.3	
AREA 7 MERRIMACK																
7a	20	2778	7655	6257	3878	7855	25645	39.9	21.3	292.1	338.1	443.4	53.3	1188.1	607.2	
7b	20	1410	12100	3635	3410	46965	66110	72.7	10.6	203.4	1111.6	132.0	45.3	1575.6	583.0	
Not Evaluated	6	868														
Authorized P.L. 566	5	808	7490	1415	885	27000	36790	14.2	17.0	49.3	283.1	19.2	38.9	421.7	377.2	73.5 - 3
Potential Flood Prev. Projects	16	1765	6520	6284	5073	16085	33962	46.4	14.9	336.8	798.5	506.6	45.6	1748.8	756.1	
Potential Developments	19	1615	5745	2193	1330	11735	21003	52.0	-	109.4	368.1	49.6	14.1	593.2	56.9	
TOTAL 3/	40	4188	19755	9892	7288	54820	91755	112.6	31.9	495.5	1449.7	575.4	98.6	2763.7	1190.2	
AREA 8 CONNECTICUT																
8a	12	1483	5113	1644	89	2241	9087	66.7		191.5		33.9	38.1	330.2	89.1	
8b	41	4691	14240	6294	617	7148	28299	111.0		633.9		347.8	212.1	1304.8	580.8	
8c	48	3101	13986	2909	1925	8281	27101	34.6		798.2		163.4	115.7	1111.9	563.5	
8d	27	1407	2854	2163	1986	8439	15442	18.3		2148.4		80.7	286.8	2534.2	833.2	
Not Evaluated	9	454														
Authorized P.L. 566	11	347	10326	615	2374	7110	20425	33.3		2367.7		110.0	316.1	2827.0	1231.3	223.2 11.0 10
Potential Flood Prev. Projects	13	1653	6766	1748	946	2817	12277	39.6		573.1		226.9	194.1	993.7	835.3	
Potential Developments	104	8682	19101	10647	1297	16182	47227	157.7		831.3		288.9	182.5	1460.4	175.3 8/	
TOTAL 3/	128	10682	36193	13010	4617	26109	79929	230.6		3772.0		625.8	652.7	5281.1	2066.6	
AREA 9 NARRAGANNSETT																
9a	44	2280	16780	3915	16390	92795	129880	419.6	-	576.1	2095.6	643.3	173.8	3908.4	595.7	
9b	29	1617	11855	3085	3390	30910	49240	76.8	-	339.1	1148.3	437.6	148.1	2149.9	577.8	
Not Evaluated	7	687			1250	7160	8410									
Authorized P.L. 566	1	8	20	380	1550	300	2250	-	-	76.7	16.6	6.4	-	99.7	18.1	- -
Potential Flood Prev. Projects	32	1663	13050	3335	6350	62860	85595	177.5	-	433.3	2002.4	622.4	139.9	3375.5	1129.3	
Potential Developments	40	2226	15565	3285	11880	60545	91275	318.9	-	405.2	1224.9	452.1	182.0	2583.1	26.1	
TOTAL 3/	73	3897	28635	7000	19780	123705	179120	496.4	-	915.2	3243.9	1080.9	321.9	6058.3	1173.5	
AREA 10 THAMES AND HOUSAT																
10a	25	1643	3505	2975	886	5610	12976	8.9	-	257.7	672.3	121.2	75.0	1135.1	785.8	
10b	63	2757	14349	12500	3609	10163	40621	30.3	11.7	1497.1	1946.6	341.0	73.2	3899.9	2171.5	
Not Evaluated	2	180														
Authorized P.L. 566	5	136	480	115	320	60	975	.6	1.2	294.1	664.3	23.7	66.8	1050.7	814.6	- - 13
Potential Flood Prev. Projects	27	1493	9601	6488	3324	12851	32264	34.6	5.1	1210.3	1212.4	339.8	76.1	2878.3	1966.9	
Potential Developments	56	2771	7773	8872	351	2862	20358	4.0	5.4	250.4	742.2	98.7	5.3	1106.0	115.9	
TOTAL 3/	88	4400	17854	15475	4495	15773	53597	39.2	11.7	1754.8	2618.9	462.2	148.2	5035.0	2897.3	
SUBREGION B																
Not Evaluated	28	2784			1250	7160	8410									
Authorized P.L. 566	24	1415	10620	3717	5199	34820	63356		116	3761		165	437	4479	2487	318 11 59
Potential Flood Prev. Projects	102	8797	44847	31702	21946	113952	212447		483	7202		1905	649	10239	5666	
Potential Developments	241	16553	48354	32523	15501	100065	196443		539	3956		899	393	5787	206	
TOTAL 3/	367	26765	112821	67942	42646	248837	472246		1138	14919		2969	1479	20505	8359	

1/ To crest of emergency spillway.
2/ Storage for beneficial uses other than flood prevention.
3/ Excludes Not Evaluated.
4/ Includes redevelopment and/or secondary benefits.
5/ Diversion ditch
6/ Dike in miles.
7/ Estimated, not i
8/ Cost includes a
Note: Inventory base

MAGES, WATER MANAGMENT AND STRUCTURAL MEASURES
SUBREGION B

Benefits and Costs																		Upstream Structural Measures							
nual Flood Damage				Benefits					Costs					No.	D.A.	Storage				Area	Channel	Other
Comm.	Trans.	Other	Total	Flood Prev.	Agr.	Rec.	Other	Total	Flood Prev.	Agr.	Rec.	Other	Total	of Dams	above Dams	Sedi-ment	Flood-water	Other Uses 2/ Alloc.	Avail.	Total	Perm. Pool	Imp.	Water-shed Imp.
& Indus.				Damage Redctn	MIU& CLU	Water Mgt.	Uses		Prev.	Water Mgt.	Uses	Avrg. Annl.	Est. Cost			1/							
thousand dollars				thousand dollars					thousand dollars						sq.mi.	thousand acre feet					ac.	miles	

UMPSCOT, SACO, PISCATAQUA RIVERS AND COASTAL

	24.0	22.6	-	66.4	55.1					187.6				619.8	11745	21	396.0	6.1	72.3	.9	156.8	236.1	8710		
	115.4	186.4	239.2	939.6	715.4					890.4		2.6		2876.5	54809	59	843.8	12.3	137.5	.4	334.3	484.5	16045		
	254.0	17.3	18.3	359.8	260.8					395.7				1541.4	28855	48	418.1	6.5	67.1	-	209.8	283.4	16346		
	7.2	5.8	15.3	80.0	45.9	21.2	-	7.2	-	86.4 4/	60.3	-	2.6	-	62.9	1698	7	44.9	.2	9.2	.4	-	9.8	86		
	375.2	209.7	233.4	1242.6	978.4					1138.6				4087.9	77335	92	1155.3	17.2	183.3	-	503.8	704.3	27689		
	11.0	9.8	8.8	43.2	7.0					274.8				886.9	16374	29	457.7	7.5	84.4	.9	197.1	289.9	13326		
	393.4	225.3	257.5	1365.8	1031.3					1473.7				5037.7	99407	128	1657.9	24.9	276.9	1.3	700.9	1004.0	41101		

AREA 7 MERRIMACK RIVER

	338.1	443.4	53.3	1188.1	607.2					1361.5				4577.2	86651	148	1138.8	17.4	171.3	3.1	490.9	682.7	26212		
	1111.6	132.0	45.3	1575.6	583.0					808.8				2603.3	51663	67	420.3	7.7	74.6	8.3	150.5	241.1	16723	.2	.2 5/
	283.1	19.2	38.9	421.7	377.2	73.5	-	349.2	-	946.3 4/	408.4			641.4	31061	53	295.9	4.6	41.0	-	133.0	178.6	12129		
	798.5	506.6	45.6	1748.8	756.1					1062.0	377.4	-	145.9	42.9 565.3	14018	41	259.5	2.6	46.4	11.0	6.7	66.7	2256	.2	.2 5/
	368.1	49.6	14.1	593.2	56.9					730.9				2558.6	48254	75	543.1	9.6	86.9	-	236.5	333.0	17675		
	1449.7	575.4	98.6	2763.7	1190.2					2170.3				7180.5	138314	215	1559.1	25.1	245.9	11.4	641.4	923.8	42935	.2	.2 5/

AREA 8 CONNECTICUT RIVER

1.5		33.9	38.1	330.2	89.1					645.4				1702.4	31239	22	420.2	3.5	66.8	-	216.5	286.8	9465		
3.9		347.8	212.1	1304.8	580.8					3123.4				8430.6	150851	157	1296.4	11.7	247.9	6.7	487.7	754.0	19373	.8	
6.2		163.4	115.7	1111.9	563.5					1462.4				3796.3	70041	101	538.8	7.2	117.2	12.6	208.6	345.6	15584	14.1	.6 5/
8.4		80.7	286.8	2534.2	833.2					1802.7				4508.3	87136 6/	92	428.8	19.4	112.1	1.1	268.7	401.3	16436	9.2	
7.7		110.0	316.1	2827.0	1231.3	223.2	11.0	102.1	4.5	1599.1 4/	323.1			994.6	18253 6/	11	31.0	.6	5.5	-	19.0	25.1	1076		
3.1		226.9	154.1	993.7	835.3						878.2	5.6	44.6	1.0 929.5	23445 6/	34	107.6	1.0	32.7	1.9	-	35.6	420	23.6	.6 5/
1.3		288.9	182.5	1460.4	175.3 6/					1566.7				3099.9	49355	63	529.9	4.8	99.0	18.5	129.2	251.5	6614	.5	
										4589.0				14498.2	266467	275	2046.7	36.0	412.3	-	1052.3	1500.6	53824		
2.0		625.8	652.7	5281.1	2066.6					7033.9				18437.6	339267 6/	372	2684.2	41.8	544.0	20.4	1181.5	1787.7	60858	24.1	.6 5/

AREA 9 NARRAGANNSETT BAY AREA

1	2095.6	643.3	173.8	3908.4	595.7					832.4				2370.4	44664	46	273.0	5.6	50.2	.6	127.8	184.2	15872	9.1	.1 6/
1	1148.3	437.6	148.1	2149.9	577.8					647.0				1604.6	30049	40	279.9	3.7	56.2	-	84.3	144.2	9321		
										21.3				75.4	1407	2	12.9	.3	2.5	-	7.2	10.0	870		6/
7	16.6	6.4	-	99.7	18.1	-	-	3.0	-	21.1 13.1	-	3.2	-	16.3	410	1	4.3	-	.9	.2	-	1.1	126	9.1	.1
3	2002.4	622.4	139.9	3375.5	1129.3					1139.3				2918.2	54822	63	344.6	6.9	63.8	.4	129.4	200.5	16399		
2	1224.9	452.1	182.0	2583.1	26.1					327.0				1040.5	19481	22	204.0	2.4	41.7	-	82.7	126.8	8668		
2	3243.9	1080.9	321.9	6058.3	1173.5					1479.4				3975.0	74713	86	552.9	9.3	106.4	.6	212.1	328.4	25193	9.1	.1 6/

EA 10 THAMES AND HOUSATONIC RIVERS

7	672.3	121.2	75.0	1135.1	725.8					1045.0				1919.1	34589	37	289.6	1.5	56.8	.2	66.7	125.2	4294	.5	
1	1946.6	341.0	73.2	3899.9	2171.5					2293.8				3992.4	77337	79	563.9	5.0	120.7	1.3	145.2	272.2	10793	3.2	
1	664.3	23.7	66.8	1056.7	814.5	-	-	135.8	-	998.5 4/	396.5	-	49.0	.3	445.8	10619	20	55.9	.2	18.8	1.5	-	20.5	423	3.5	
3	1212.4	339.8	76.1	2878.3	1966.9					2139.7				3857.2	71128	63	516.9	6.0	97.4	-	128.6	232.0	8361	.2	
4	742.2	98.7	5.3	1106.0	115.9					802.6				1608.5	30179	33	280.7	.3	61.3	-	83.3	144.9	6303		
8	2618.9	462.2	148.2	5035.0	2897.3					3338.8				5911.5	111926	116	853.5	6.5	177.5	1.5	211.9	397.4	15087	3.7	

SUBREGION B

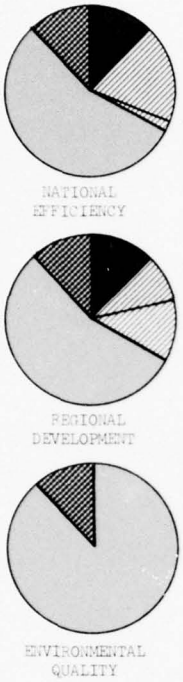
3761	165	437	4479	2487	318	11	597	4	3651 4/	753				2711	50721 6/	66	340	6	49	-	159	214	14075		5/ 6/
7202	1905	649	10239	5666						1726	6	245	43	2020	50190 6/	103	472	4	108	15	7	134	3311	36	1 .1
3956	899	393	5787	206						7046				17930	328682	380	3302	48	556	19	1289	1912	82067	1	
										6724				20593	380755	434	3532	56	687	1	1652	2396	99796		
4919	2969	1479	20505	8359						15496				40543	759627	917	7307	108	1351	35	2948	4442	185174	37	1 5/ .1 6/

5/ Diversion ditch in miles.
6/ Dike in miles.
7/ Estimated, not included in totals.
8/ Cost includes a diversion channel, a flood water diversion, and a training dike.
Note: Inventory base 1966; Price base 1970; Ammortization rate, 5-1/8% over 100 years.

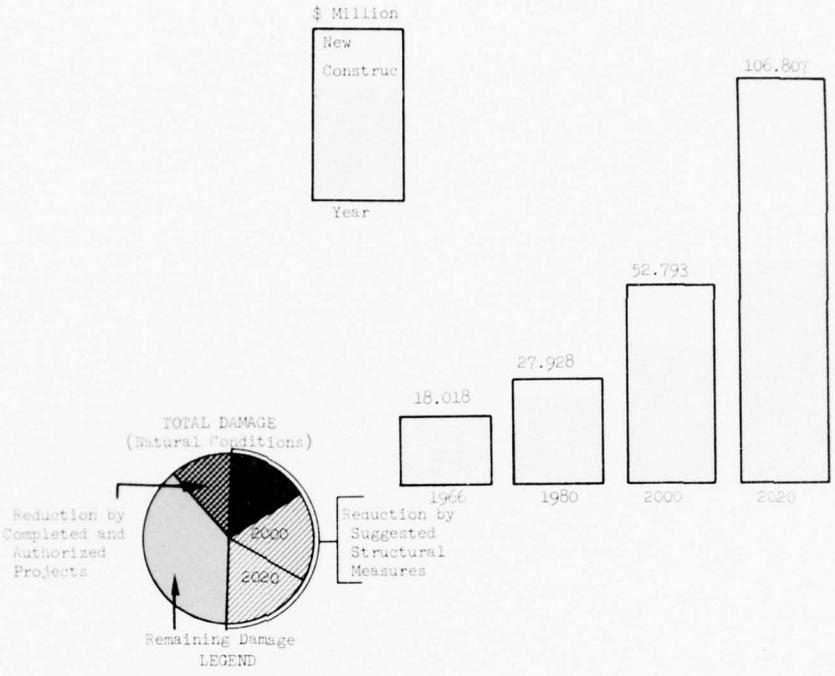
SUBREGION B
TABLE F-5

FLOOD DAMAGE DISTRIBUTION AND PROJECTIONS

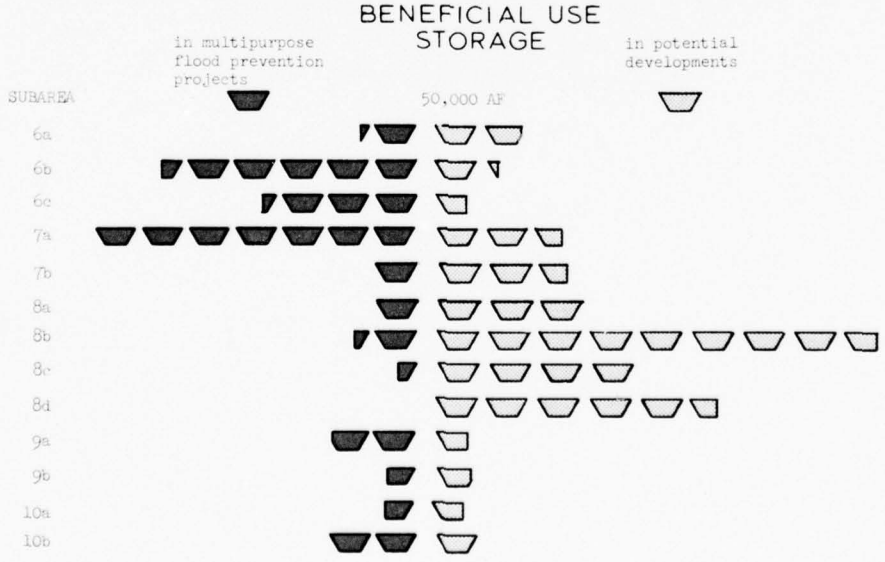
DISTRIBUTION

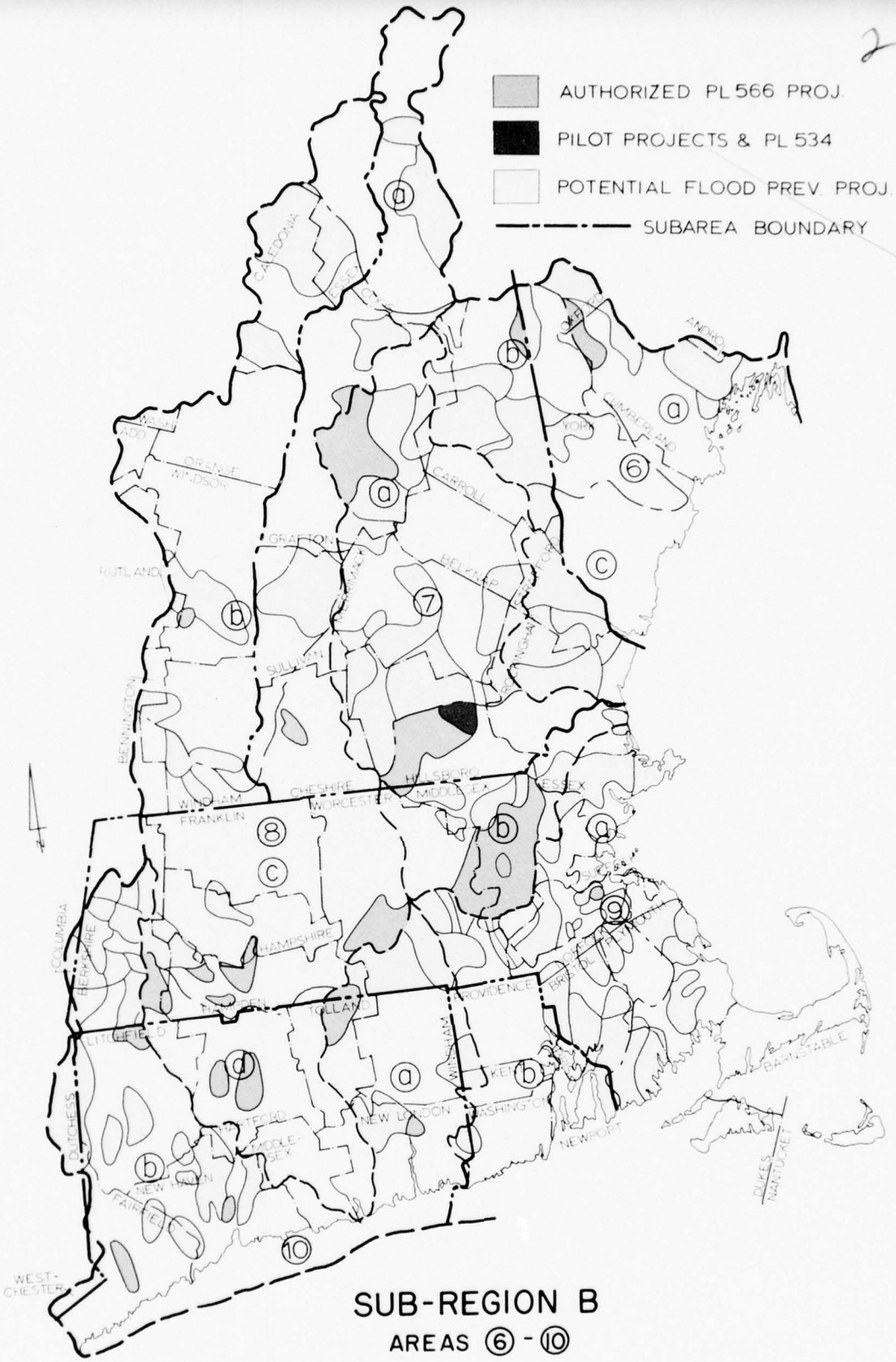


PRESENT AND PROJECTED AVERAGE ANNUAL DAMAGES



POTENTIAL WATER SUPPLY FROM UPSTREAM RESERVOIRS





SUB-REGION B
AREAS ⑥ - ⑩

UPSTREAM FLOOD PREVENTION PROJECTS

FIGURE F-20

USDA-SCS-HYATTSVILLE, MD. 1971

SUBREGION C (Areas 11, 12 and 13)

Area 13 was not included in the upstream analysis because of its urban character.

Flooding

Area inundated. Total area inundated by the 100 year frequency flood in the Subregion is approximately 518,000 acres (Table F-6). Of this, 15 percent is in crop and pasture, 35 percent is in forest land, and 50 percent is in urban and miscellaneous.

Area 12 has the larger area inundated (382,000 acres). The larger acreage inundated in crop and pasture is in Area 11 (45,000). The larger acreage inundated in forest land is in Area 12 (143,000). The larger acreage inundated in urban and miscellaneous is in Area 12 (205,000).

Area inundated as a percent of total area for the Subregion is 4. The values for Areas 11 and 12 were 2 percent and 5 percent respectively.

Present Damages. The present average annual damage in the Subregion is approximately $5.1 million. The values for Areas 11 and 12 were $0.8 million and $4.4 million respectively. For the Subregion 21 percent is agricultural, and 79 percent is nonagricultural. The percent agricultural damage for Areas 11 and 12 were 48 percent and 16 percent respectively.

The present average annual damage in dollars per acre of area inundated for Areas 11 and 12 were $6. and $12. respectively. The average for the Subregion is $10.

There are two authorized PL 566 projects in upstream areas which will reduce present average annual damage by $0.22 million, leaving a damage of $0.03 million. Present average annual damage in the remaining upstream areas is $5.10 million.

Future Damages. If no additional flood prevention measures were installed, the present average annual flood damages of $5.1 million would increase to $7.4 million in 1980, $13.1 million in 2000, and $24.0 million in 2020 (Figure F-21). The annual damages in 2020 for Areas 11 and 12 were $2.9 million and $21.3 million respectively.

Extent and Timing of Flood Prevention Measures

Structural Measures. Suggested flood prevention structural measures involving installation of 78 multiple purpose dams with 93,800 acre feet of flood prevention storage and 25 miles of channel improvement at an average annual cost of $1.24 million will reduce annual flood damage by $3.40 million in 2020. The tables on

pages F-62, 63 and 64 indicate the extent and timing of potential flood prevention structural measures for each objective by Area.

The installation of structures involving National Forest land will depend upon further analysis to determine compatability with National Forest purposes.

Flood Plain Management. Flood prevention plans for the 519,000 acre flood plain should include nonstructural measures or devices as alternatives, in combination, and/or in addition to structural measures. With all potential flood prevention structural measures installed, the annual damages remaining would be $5.9 million, $10.5 million, and $19.1 million in 1980, 2000, and 2020 respectively (Figure F-21). Flood plain management of the 43,000 acres subject to high damages, would reduce this remaining damage.

Water Management

In the two authorized PL 566 projects there are included 200 acre feet of storage for uses other than flood prevention in multiple purpose reservoirs. As of 1967 under the CO program of the USDA, technical assistance was provided for the installation of about 500 miles of diversions, and 900 miles of tile, and 1500 miles of open main ditches for drainage and flood prevention. Also installed were about 11,100 ponds for flood prevention, irrigation, recreation, fish and wildlife, livestock, rural domestic, and fire protection.

In addition to flood prevention storage in the Potential Flood Prevention Projects, there is storage of 0.20 million acre feet for other uses. There are about 1.84 million acre feet of storage for other uses in the Potential Developments. The total available for water management in potential upstream impoundments is 2.04 million acre feet. The specific needs for water will be identified in other appendices.

Programs and Activities

PL 566. As of 1967 there were two authorized PL 566 projects in the Subregion; one is in Area 11, and one is in Area 12. Flood prevention storage of 8,400 acre feet and 200 acre feet of storage for other uses are included in 8 dams. The total estimated cost is $4.5 million.

RC&D. There is one RC&D project in the Subregion. A portion of the East Central Vermont RC&D project is located in Area 11. It was a desire of the sponsors that the land, water, plant, and wildlife resources be fully developed, conserved, and used for the benefit of people.

New England-New York Inter-Agency Committee Report. All of Areas 11 and 12 are included in this report. The principal authorization for the survey was Section 205 of the Rivers and

Harbors and Flood Control Act approved May 17, 1950. The principal subjects are discussions of the river basins, economic development, storage and stream flow regulation, water supply, pollution control, flood control and drainage, power development, navigation and beach erosion, fish and wildlife, recreation, management of agricultural and forest lands, minerals and insect control.

SUBREGION C - AREA 11

Floods of 100 year frequency magnitude inundate about 137,136 acres. Land use in this flood plain consists of 45,171 acres of cropland and pasture, 39,210 acres of forest, 511 acres of built-up, and 52,244 acres of miscellaneous lands.

Floods presently cause an estimated $767,800 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $1,051,900 in 1980; $1,627,700 in 2000; and $2,863,900 in 2020.

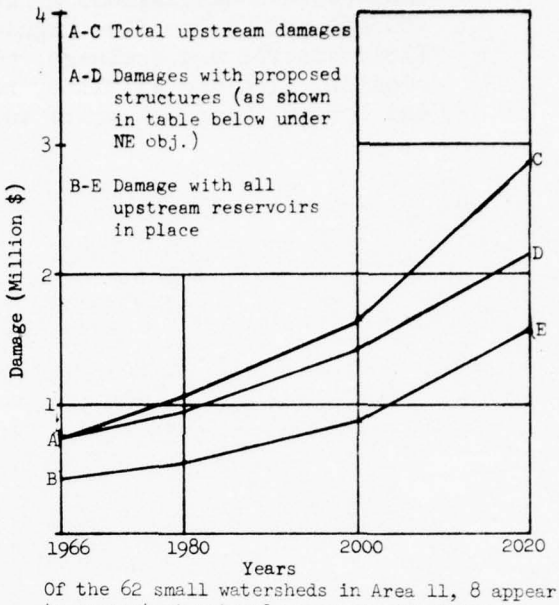
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 7,140,000 acres of land in Area 11, 2,142,000 acres require treatment and are feasible to treat. A net 1,393,000 acres will change use by 2020. Land use (1966) in the 111 watersheds consists of 1,222,000 acres of cropland, 920,000 acres of pasture, 4,427,000 acres of forest, 132,000 acres of urban, and 439,000 acres of other land.

Fully utilized, 255 potential upstream reservoir sites would have 778,700 acre feet of storage at an average cost of $141/acre foot. Allotment of the storage capacity is 38% for sediment and floodwater and 62% for other beneficial uses.

The release of 964 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 623 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
11,050 acres in 15 pools over 500 acres in size
10,420 acres in 40 pools 200-500 acres in size
8,530 acres in 68 pools 100-200 acres in size
6,930 acres in 136 pools less than 100 acres in size.
Average depths are 12 feet, 14 feet, 12 feet and 12 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 62 small watersheds in Area 11, 8 appear to warrant structural measures with flood prevention as a primary use. The 49 reservoirs with 32,700 acre feet of temporary storage could reduce flood damage by 24%. These 8 upstream watersheds deserve further study for early action projects. Another 240,600 acre feet of temporary storage in 206 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 1.9% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 70,000 acres in the 10 year and 110,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed Protection by Land Treatment (1000 Ac.)	Flood Mgt.	Structural Measures: Plain Projects No.	Multi-purpose Dams No.	Storage Total (1000 Ac.Ft.)	Storage Flood Prev. (1000 Ac.Ft.)	Channel Impr. (Mi.)	Cost: Structural Measures One Time Total ($ million)	Cost: Structural Measures One Time Flood Prev. ($ million)	Cost: Structural Measures Avg.Ann.* Total ($ million)	Cost: Structural Measures Avg.Ann.* Flood Prev. ($ million)	Benefits: Str.Measures % Damage Reduction	Benefits: Str.Measures Area Perm. Pool 1000 Ac.
	1966			1	4	1	1	-						
NATIONAL EFFICIENCY														
	1980	42	1	2	12	36	14	1	4.7	1.6	.3	.1	6	1.7
	2000	33	-	1	12	20	4	3	3.6	1.8	.2	.1	5	1.4
	2020	107	1	5	25	52	17	18	8.6	3.4	.5	.2	14	2.7
REGIONAL DEVELOPMENT														
	1980	75	1	3	24	56	18	4	8.4	3.4	.5	.2	11	3.2
	2000	93	-	3	7	8	6	18	3.7	3.7	.2	.2	10	.9
	2020	129	1	7	37	107	53	4	13.8	5.7	1.2	.5	6	2.9
ENVIRONMENTAL QUALITY														
	1980	428	23	-										
	2000	857	62	-										
	2020	857	52	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION C - AREA 12

Floods of 100 year frequency magnitude inundate about 384,314 acres. Land use in this flood plain consists of 34,247 acres of cropland and pasture, 144,259 acres of forest, 2,903 acres of built-up, and 202,905 acres of miscellaneous lands.

Floods presently cause an estimated $4,360,300 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $6,366,000 in 1980; $11,598,400 in 2000; and $21,321,900 in 2020.

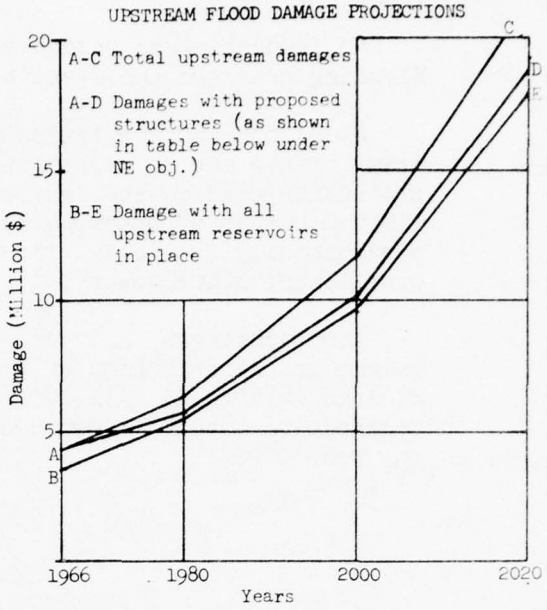
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 8,293,000 acres of land in Area 12, 2,034,000 acres require treatment and are feasible to treat. A net 1,337,000 acres will change use by 2020. Land use (1966) in the 132 watersheds consists of 1,296,000 acres of cropland, 704,000 acres of pasture, 5,202,000 acres of forest, 309,000 acres of urban, and 701,000 acres of other land.

Fully utilized, 265 potential upstream reservoir sites would have 2,212,600 acre feet of storage at an average cost of $140/acre foot. Allotment of the storage capacity is 29% for sediment and floodwater and 71% for other beneficial uses.

The release of 3,223 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 2,083 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
39,450 acres in 46 pools over 500 acres in size
26,950 acres in 87 pools 200-500 acres in size
8,900 acres in 62 pools 100-200 acres in size
2,800 acres in 41 pools less than 100 acres in size.
Average depths are 18 feet, 21 feet, 23 feet and 22 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 132 small watersheds in Area 12, 9 appear to warrant structural measures with flood prevention as a primary use. The 29 reservoirs with 51,200 acre feet of temporary storage could reduce flood damage by 13%. These 9 upstream watersheds deserve further study for early action projects. Another 509,400 acre feet of temporary storage in 236 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 4.6% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 231,000 acres in the 10 year and 327,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment 1000 Ac.	Flood Plain Mgt.	Structural Measures: Projects No.	Multi-purpose Dams No.	Storage: Total 1000 Ac.Ft.	Flood Prev.	Channel Impr. Mi.	Cost: Structural Measures: One Time Total	One Time Flood Prev.	Avg.Ann.* Total	Avg.Ann.* Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool 1000 Ac.
									$ million					
	1966			1	4	8	7	-						
NATIONAL EFFICIENCY														
	1980	156	4	7	25	176	52	-	23.5	7.2	1.3	.4	10	60.2
	2000	31	3	2	4	15	7	-	20.2	7.3	1.1	.4	3	.6
	2020	-	5	-										
REGIONAL DEVELOPMENT														
	1980	17	4	8	28	183	57	-	24.5	7.5	1.3	.4	10	60.4
	2000	15	3	1	1	7	3	-	19.2	7.7	1.0	.4	3	.4
	2020	-	5	-										
ENVIRONMENTAL QUALITY														
	1980	407	20	6	15	94	32	-	14.7	5.5	.8	.3	5	26.4
	2000	814	161	-										
	2020	814	203	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION C - Area 13

No inundation or damage estimates for upstream areas were made. Flooding problems and remedial measures are discussed in Appendix E.

Flooding characteristics are unique to this highly urbanized area. There are no major river basins in the area. Evaluation procedures used in the rest of the Region are not applicable to limited number of upstream drainage areas. Flood damages are predominantly from tidal flooding, man-made obstructions, and overflowing storm sewers.

Land treatment, use changes, protection and management affect volume and distribution of water yield. Of the 1,053,000 acres of land in Area 13, 112,000 acres require treatment and are feasible to treat. A net 396,000 acres will change land use by the year 2020.

UPSTREAM FLOOD DAMAGES, WATER MANAGEMENT AND
SUBREGION C

Subarea Project Classification	General Watershed Data: Number of Projects	Total Watershed Area sq.mi.	Area Inundated by 100 Year Freq. Flood: Crop & Pasture ac.	Woodlands ac.	Other: Urban ac.	Other: Misc. ac.	Total ac.	Pertinent Flood Plain Information: Total	Average Annual Flood Damage: Crop	Other: Agr.	Resid. & Indus:	Comm.	Trans.	Other	Total	Benefits: Flood Prev.: Damage Redctn	Agr.: Water: CLU	Rec.: Mgt.	Other: Use
									thousand dollars							thousand dollars			
AREA 11 ST. LAWRENCE RIVER AND LAKE CHA																			
11a	52	6384	43339	19775	510	37711	101335	244.0	133.9	193.0	57.3	156.9	20.4	805.5	405.3				
11b	10	958	1832	19435	1	14533	35801	11.7	-	-	-	-	-	11.7	2.6				
Not Evaluated	49	4558																	
Authorized P.L. 566	1	20	250	50	50	-	350	.8	.3	27.9	10.4	9.8	9.4	58.6	49.4	5.3	-	-	
Potential Flood Prev. Projects	8	949	14413	1874	65	5642	21994	95.8	50.2	72.4	10.6	40.3	7.9	277.2	185.9				
Potential Developments	53	6373	30508	37286	396	46602	114792	159.1	83.4	92.7	36.3	106.8	3.1	481.4	172.6				
TOTAL 3/	62	7342	45171	39210	511	52244	137136	255.7	133.9	193.0	57.3	156.9	20.4	817.2	407.9				
AREA 12 HUDSON RIVER																			
12a	16	1274	2668	9684	57	19481	31860	11.3	-	16.6	8.5	1.5	1.7	39.6	18.7				
12b	77	7089	17122	74685	1584	88821	182152	91.1	139.1	588.5	1519.8	450.1	124.2	2908.8	475.2				
12c	39	4912	14010	58643	1262	93551	167466	367.7	16.3	344.2	568.7	243.9	46.0	1580.8	380.7				
Not Evaluated	0																		
Authorized P.L. 566	1	74	285	7	48	14	354	4.8	-	38.1	51.0	60.7	30.1	184.7	168.9	-	-	46.8	
Potential Flood Prev. Projects	9	1191	12558	9009	793	14905	37265	356.2	51.0	344.2	455.9	101.0	78.6	1386.9	555.4				
Potential Developments	122	12010	20957	133906	2062	186934	343859	109.1	94.4	567.0	1590.1	533.8	63.2	2957.6	150.3				
TOTAL 3/	132	13275	33800	142922	2903	201853	381478	470.1	145.4	949.3	2097.0	695.5	171.9	4529.2	874.6				
Not Evaluated	21	1902																	
AREA 13 LONG ISLAND AND COASTA																			
SUBREGION C																			
Not Evaluated	70	6460																	
Authorized P.L. 566	2	94	535	57	98	14	704	6	-	66	61	71	40	244	218	5	-	47	
Potential Flood Prev. Projects	17	2140	26971	10883	858	20547	59259	452	101	417	466	141	86	1663	741				
Potential Developments	175	18383	51465	171192	2888	73006	458651	268	178	660	1626	640	66	3438	323				
TOTAL 3/	194	20617	78971	182132	3414	284097	518614	726	279	1143	2153	852	192	5345	1282				

1/ To crest of emergency spillway.
2/ Storage for beneficial uses other than flood prevention.
3/ Excludes Not Evaluated.
4/ Includes redevelopment and/or secondary benefits.
Note: Inventory base 1966; Price base 1970; Ammortization rate, 5-1/8% over 100 years.

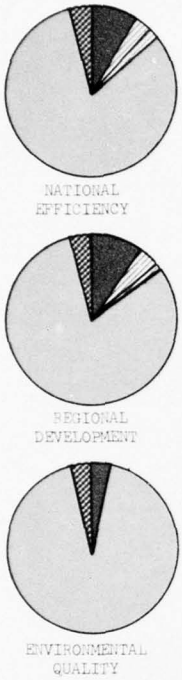
R MANAGEMENT AND STRUCTURAL MEASURES
UBREGION C

Benefits and Costs												Upstream Structural Measures						
Benefits						Costs							Storage				Area	Channel
er: Total	Flood Prev.: Damage: Redctn:	Agr.: Rec.: MIUR: Mgt.:	Water:	Other: Uses	Total	Flood: Prev.:	Agr.: Water: Mgt.	Rec.: Uses	Other: Total: Avrg.: Annl.:	Total Est. Cost	No. of Dams	D.A. above Dams	Sedi-: ment	Flood-: water 1/	Other Uses 2/: Alloc.:	Avail.:	Total: Pool	Perm.: Imp.
	thousand dollars					thousand dollars						sq.mi.	thousand acre feet				ac.	miles
RIVER AND LAKE CHAMPLAIN AREA																		
.4	805.5	405.3			2251.2				5295.2	99450	254	2686.4	21.9	251.2	.5	411.4	685.0	34161	31.5
-	11.7	2.6			182.2				650.5	12198	5	144.5	3.9	23.0	-	67.8	94.7	2775	
.4	58.6	49.4	5.3	- - -	54.7	36.7	- - -		36.7	899	4	6.6	.1	.9	-	-	1.0	8	
.9	277.2	185.9			433.4				918.4	17134	49	347.2	1.8	32.7	-	72.5	107.0	5881	25.3
.1	481.4	172.6			1963.3				4990.6	93614	206	2477.1	23.9	240.6	.5	406.7	671.7	31047	6.2
.4	817.2	407.9			2433.4				5945.7	111647	259	2830.9	25.8	274.2	.5	479.2	779.7	36936	31.5
12 HUDSON RIVER																		
.7	39.6	18.7			705.0				2142.0	40164	25	332.9	8.9	53.2	-	170.9	233.0	6354	
.2	2908.8	475.2			2278.9				7636.6	143791	147	2101.9	54.6	337.8	.2	959.7	1352.3	48143	
.0	1580.8	380.7			2538.2				6922.5	130009	97	1209.2	29.6	176.4	-	428.9	634.9	23597	
.1	184.7	168.9	- -	46.8 -	235.5 4/	136.4	- 8.8 -		145.2	3554	4	34.2	.6	6.8	.2	-	7.6	59	
8.6	1286.9	555.4				806.2			2340.8	43814	29	329.9	8.1	51.2	-	130.9	190.2	7553	
3.2	2957.6	150.3				4579.5			14215.1	266596	236	3279.9	84.4	509.4	-	1428.6	2022.4	70482	
.9	4529.2	874.6				5522.1			16701.1	313964	269	3644.0	93.1	567.4	.2	1599.5	2226.2	78094	
ISLAND AND COASTAL AREA																		
UBREGION C																		
0	244	218	5	- 47	- 290 4/	173	- 9 -		182	4453	8	41	1	8	-	-	9	67	
6	1663	741				1240			3259	60948	78	677	10	84	-	203	297	13434	25
6	3438	323				6543			19206	360210	442	5757	108	750	1	1835	2694	101529	6
2	5345	1282				7956			22648	425611	528	6475	119	842	1	2038	3000	115030	31

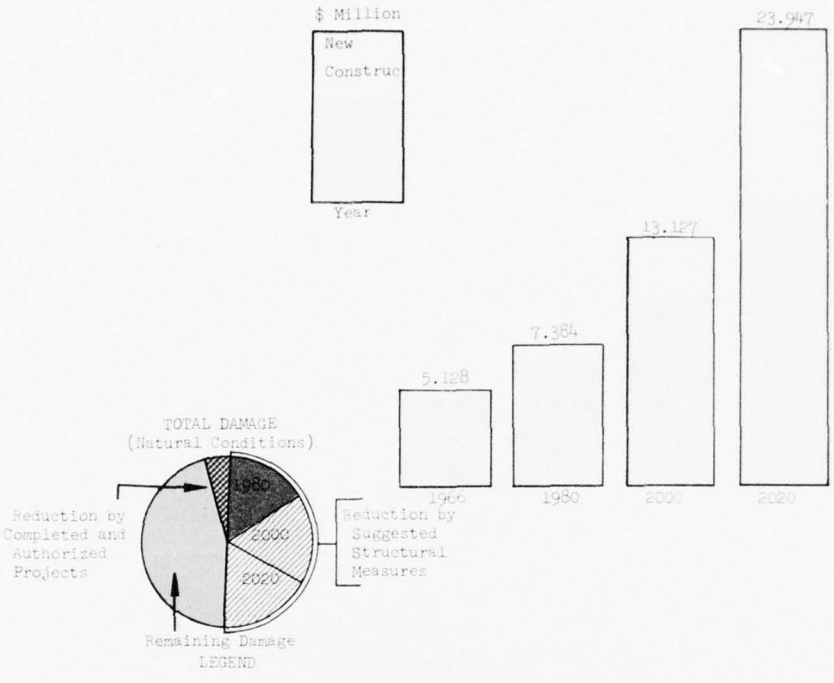
SUBREGION C
TABLE F-6

FLOOD DAMAGE DISTRIBUTION AND PROJECTIONS

DISTRIBUTION

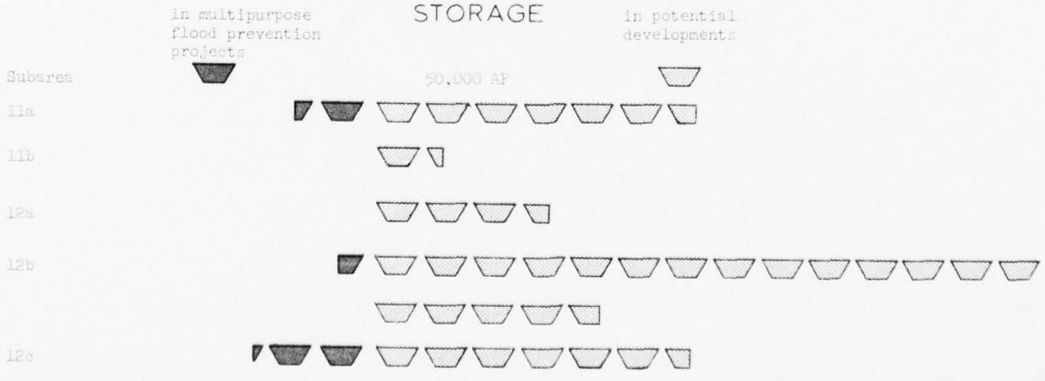


PRESENT AND PROJECTED AVERAGE ANNUAL DAMAGES



POTENTIAL WATER SUPPLY FROM UPSTREAM RESERVOIRS

BENEFICIAL USE STORAGE



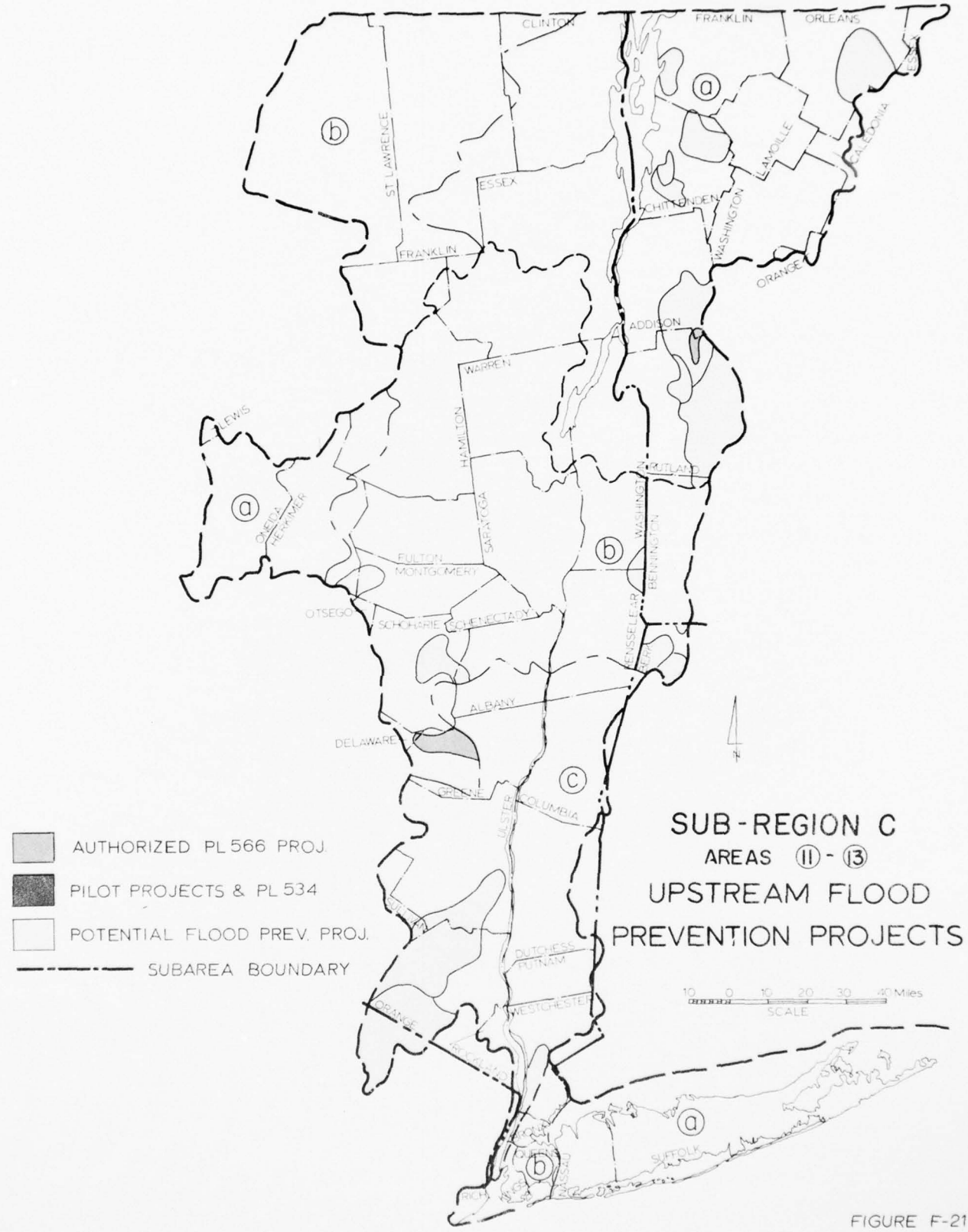


FIGURE F-21

USDA-SCS-HYATTSVILLE, MD. 1971

SUBREGION D (Areas 14, 15 and 16)

Flooding

Area Inundated. Total area inundated by the 100 year frequency flood in the Subregion is approximately 1.27 million acres (Table F-7). Of this, 31 percent is in crop and pasture, 26 percent is in forest land, and 43 percent is in urban and miscellaneous.

Area 15 has the greatest and Area 14 has the least total area inundated. Area inundated in crop and pasture for Areas 14, 15 and 16 are 12,700 acres, 378,300 acres and 5,500 acres respectively. Area 15 is second to Area 18 in area inundated in crop and pasture. Area inundated in forest land for Areas 14, 15 and 16 are 17,100 acres, 195,100 acres, and 119,500 acres respectively. Area inundated in urban and miscellaneous for Areas 14, 15 and 16 are 30,600 acres, 309,300 acres, and 203,700 acres respectively.

Area inundated as a percent of total area for the Subregion is 11. The values for Areas 14, 15 and 16 are 4, 11, and 23 respectively. Area 16 is second to Area 18 in area inundated as a percent of total area.

Present Damages. The present average annual damage in the Subregion is approximately $5.5 million. It ranged from $0.1 million in Area 16 to $4.3 million in Area 15. For the Subregion, 28 percent is agricultural, and 72 percent is nonagricultural. The percent agricultural damage ranged from 8 percent in Area 14 to 41 percent in Area 16.

The present average annual damage in dollars per acre of area inundated ranged from less than one dollar in Area 16 to $18. in Area 14. The average for the Subregion is $6. Area 16 has the lowest damageable value per acre inundated in the Region.

There are 21 authorized PL 566 projects and one Pilot Watershed in upstream areas which will reduce present average annual damage by $1.7 million, leaving a damage of $0.4 million. Present average annual damage in the remaining upstream areas is $5.1 million.

Future Damages. If no additional flood prevention measures were installed, the present average annual flood damages of $5.5 million would increase to $7.8 million in 1980, $13.3 million in 2000, and $24.3 million in 2020 (Figure F-22). The range in annual damage in 2020 would be $0.3 million in Area 16 to $18.5 million in Area 15.

Extent and Timing of Flood Prevention Measures

Structural Measures. Suggested flood prevention structural measures involving installation of 89 multiple purpose dams

with 132,800 acre feet of flood prevention storage and 380 miles of channel improvement at an average annual cost of $1.68 million will reduce annual flood damage by $11.70 million in 2020. The tables on pages F-68, 69 and 70 indicate the extent and timing of potential flood prevention structural measures by Area.

Flood Plain Management. Flood prevention plans for the 1.3 million acre flood plain should include nonstructural measures or devices as alternatives, in combination, and/or in addition to structural measures. With all potential flood prevention structural measures installed, the annual damages remaining would be $3.3 million, $5.6 million, and $10.2 million in 1980, 2000 and 2020 respectively (Figure F-22). Flood plain management of the 261,000 acres subject to high damages, would reduce this remaining damage.

Water Management

In the 21 authorized PL 566 projects and one Pilot Watershed there are included 47,700 acre feet of storage for uses other than flood prevention in multiple purpose reservoirs. As of 1967 under the CO program of the USDA technical assistance was provided for the installation of about 1,000 miles of diversions, 1,500 miles of tile, and 2,400 miles of open main ditches for drainage and flood prevention. Also installed were about 5,000 ponds for flood prevention, irrigation, recreation, fish and wildlife, livestock, rural domestic, and fire protection.

In addition to flood prevention storage in the Potential Flood Prevention Projects, there is storage of 0.29 million acre feet for other uses. There are about 1.06 million acre feet of storage for other uses in the Potential Developments. The total available for water management in potential upstream impoundments is 1.35 million acre feet. The specific needs for water will be identified in other appendices.

Programs and Activities

PL 566. As of 1967 there were 21 authorized PL 566 projects and one Pilot Watershed in the Subregion; one is in Area 14, and 21 are in Area 15. Flood prevention storage of 73,200 acre feet and 47,700 acre feet of storage for other uses are included in 86 dams. The total estimated cost is $70.1 million.

Delaware River Basin (Area 15). The history of planning for the development and utilization of the water resources of this basin dates from the early 1800's. In 1933 the Corps of Engineers completed preliminary studies of the Delaware River that were submitted to Congress and became part of the nationwide study known as the "308" report. The Committee on Public Works, U. S. Senate, on April 13, 1950, adopted the first of several resolutions that authorized a Comprehensive Survey of the Water Resources of the Delaware River Basin. The report was published in December, 1960.

The Chief of Engineers recommended that Congress adopt the comprehensive plan present in the report. In 1961, the Delaware River Basin Compact became law creating the Delaware River Basin Commission. The Commission is an agency and instrumentality of the principals; The United States of America, the State of Delaware, the State of New Jersey, the State of New York, and the Commonwealth of Pennsylvania. Eight major multiple purpose reservoir projects contained in the Corps of Engineers' comprehensive plan were included in the Delaware River Basin Commission's Comprehensive Plan, Phase 1 (adopted March 28, 1962) and authorized by Congress in the Flood Control Act of 1962 (P.L. 87-874 of October 23, 1962).

Type IV Cooperative Survey. The Appalachian Region Water Resources Study was recently completed. The upper western portion of Area 15 is included in this study.

SUBREGION D - AREA 14

Floods of 100 year frequency magnitude inundate about 60,365 acres. Land use in this flood plain consists of 12,685 acres of cropland and pasture, 17,100 acres of forest, 2,125 acres of built-up, and 28,455 acres of miscellaneous lands.

Floods presently cause an estimated $1,050,400 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $1,575,600 in 1980; $2,878,100 in 2000; and $5,420,100 in 2020.

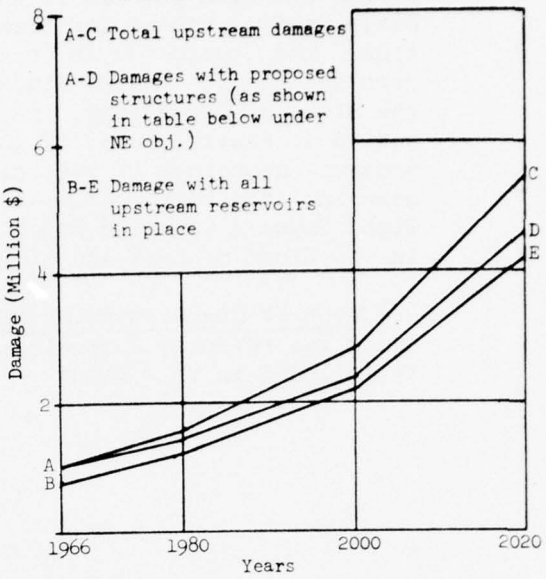
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 1,472,000 acres of land in Area 14, 461,000 acres require treatment and are feasible to treat. A net 668,000 acres will change use by 2020. Land use (1966) in the 22 watersheds consists of 229,000 acres of cropland, 45,000 acres of pasture, 588,000 acres of forest, 448,000 acres of urban, and 162,000 acres of other land.

Fully utilized, 62 potential upstream reservoir sites would have 352,700 acre feet of storage at an average cost of $164/acre foot. Allotment of the storage capacity is 23% for sediment and floodwater and 77% for other beneficial uses.

The release of 509 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 329 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
5,280 acres in 6 pools over 500 acres in size
5,570 acres in 17 pools 200-500 acres in size
3,410 acres in 23 pools 100-200 acres in size
1,020 acres in 16 pools less than 100 acres in size.
Average depths are 12 feet, 18 feet, 20 feet and 39 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 16 small watersheds in Area 14, 8 appear to warrant structural measures with flood prevention as a primary use. The 20 reservoirs with 19,100 acre feet of temporary storage could reduce flood damage by 13%. These 8 upstream watersheds deserve further study for early action projects. Another 51,400 acre feet of temporary storage in 42 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 4.1% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 44,000 acres in the 10 year and 51,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment	Flood Plain Mgt.	Structural Measures: Projects	Multi-purpose Dams	Storage: Total	Flood Prev.	Channel Impr.	Cost: Structural Measures: One Time Total	Avg.Ann.* Flood Prev.	Avg.Ann.* Total	Benefits: Str.Measures: % Flood Damage Reduction	Area Perm. Pool
		1000 Ac.		No.	No.	1000 Ac.Ft.		Mi.	$ million				1000 Ac.
	1966			1	8	1	1	-					
NATIONAL EFFICIENCY													
	1980	10	3	1	2	9	2	-	1.4	1.4	.1	4	.3
	2000	132	2	7	18	92	20	-	15.3	5.1	.9	10	4.0
	2020	-	5	-									
REGIONAL DEVELOPMENT													
	1980	10	3	1	2	9	2	-	1.4	1.4	.1	4	.3
	2000	132	2	7	18	92	20	-	15.3	5.1	.9	10	4.0
	2020	48	4	2	12	72	17	-	11.2	1.6	.7	2	3.1
ENVIRONMENTAL QUALITY													
	1980	92	9	8	20	101	22	-	16.7	6.5	1.0	13	4.3
	2000	184	23	7	42	251	60	-	40.7	10.6	2.3	8	10.7
	2020	184	28	-									

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

Floods of 100 year frequency magnitude inundate about 882,657 acres. Land use in this flood plain consists of 378,265 acres of cropland and pasture, 195,108 acres of forest, 59,030 acres of built-up, and 250,254 acres of miscellaneous lands.

Floods presently cause an estimated $4,338,900 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $6,161,2000 in 1980; $10,283,200 in 2000; and $18,527,100 in 2020.

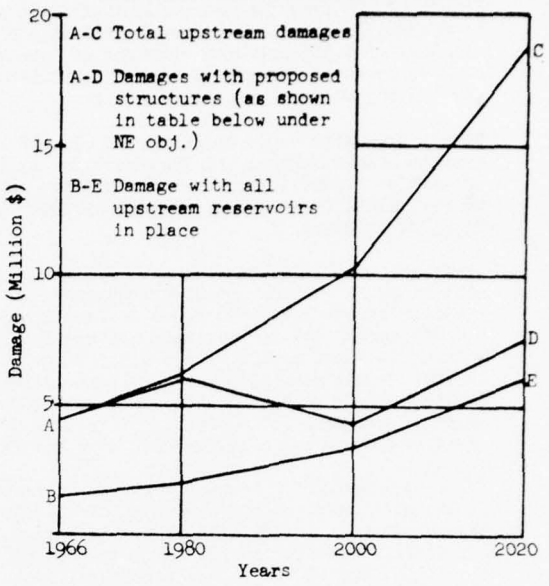
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 7,965,000 acres of land in Area 15, 2,681,000 acres require treatment and are feasible to treat. A net 2,344,000 acres will change use by 2020. Land use (1966) in the 137 watersheds consists of 1,811,000 acres of cropland, 459,000 acres of pasture, 4,048,000 acres of forest, 799,000 acres of urban, and 848,000 acres of other land.

Fully utilized, 350 potential upstream reservoir sites would have 1,469,000 acre feet of storage at an average cost of $217/acre foot. Allotment of the storage capacity is 32% for sediment and floodwater and 68% for other beneficial uses.

The release of 1,841 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 1,190 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
23,600 acres in 28 pools over 500 acres in size
20,050 acres in 66 pools 200-500 acres in size
11,580 acres in 82 pools 100-200 acres in size
1,850 acres in 155 pools less than 100 acres in size.
Average depths are 13 feet, 19 feet, 17 feet and 16 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 137 small watersheds in Area 15, 26 appear to warrant structural measures with flood prevention as a primary use. The 69 reservoirs with 95,300 acre feet of temporary storage could reduce flood damage by 59%. These 26 upstream watersheds deserve further study for early action projects. Another 313,800 acre feet of temporary storage in 281 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 11.1% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 600,000 acres in the 10 year and 803,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment	Flood Plain Mgt.	Structural Measures: Projects	Multi-purpose Dams	Storage: Total	Flood Prev.	Channel Impr.	Cost: Structural Measures: One Time: Total	Flood Prev.	Avg.Ann.* Total	Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool
		1000 Ac.		No.	No.	1000 Ac.Ft.		Mi.	$ million					1000 Ac.
	1966			21	78	120	72	74						
NATIONAL EFFICIENCY														
	1980	29	81	4	6	15	4	1	3.2	1.6	.2	.1	3	.8
	2000	542	-	22	63	307	106	379	56.5	23.7	3.1	1.3	57	14.7
	2020	-	22	-										
REGIONAL DEVELOPMENT														
	1980	155	74	10	16	61	19	91	9.3	3.1	.6	.2	21	6.3
	2000	416	-	16	53	262	92	289	50.4	22.2	2.7	1.2	38	9.2
	2020	126	27	6	19	76	24	1	16.7	5.6	.9	.3	1	3.1
ENVIRONMENTAL QUALITY														
	1980	536	248	26	69	322	110	380	59.7	25.3	3.3	1.4	59	15.2
	2000	1072	384	45	141	573	180	-	129.6	48.8	6.9	2.6	4	22.9
	2020	1072	250	45	140	572	179	-	129.6	48.8	6.9	2.6	4	22.9

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION D - AREA 16

Floods of 100 year frequency magnitude inundate about 328,715 acres. Land use in this flood plain consists of 5,505 acres of cropland and pasture, 119,495 acres of forest, 52 acres of built-up, and 203,663 acres of miscellaneous lands.

Floods presently cause an estimated $72,500 average annual damage. Wi hout meeting any flood prevention demands, projected damages are expected to be: $103,700 in 1980; $168,200 in 2000; and $306,700 in 2020.

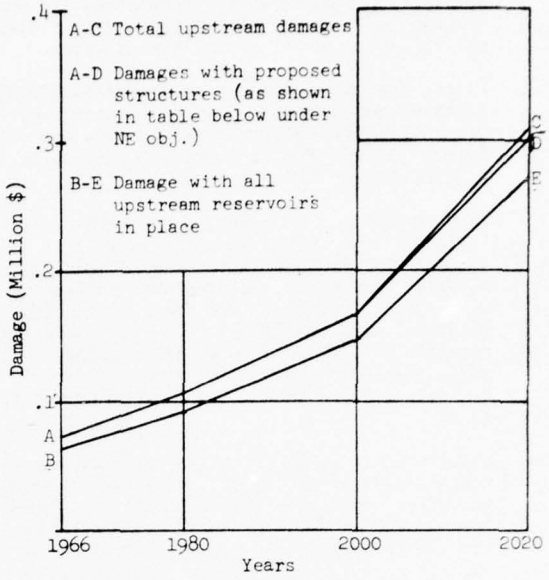
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 1,409,000 acres of land in Area 16, 616,000 acres require treatment and are feasible to treat. A net 218,000 acres will change use by 2020. Land use (1966) in the 14 watersheds consists of 212,000 acres of cropland, 21,000 acres of pasture, 760,000 acres of forest, 204,000 acres of urban, and 212,000 acres of other land.

Fully utilized, 20 potential upstream reservoir sites would have 125,600 acre feet of storage at an average cost of $81/acre foot. Allotment of the storage capacity is 30% for sediment and floodwater and 70% for other beneficial uses.

The release of 241 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 156 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
6,530 acres in 7 pools over 500 acres in size
2,880 acres in 8 pools 200-500 acres in size
760 acres in 5 pools 100-200 acres in size.
Average depths are 9 feet, 8 feet, and 8 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 14 small watersheds in Area 16, 0 appear to warrant structural measures with flood prevention as a primary use.

Temporary storage in 20 reservoirs, of 32,700 acre feet could possibly be developed in project with flood prevention as a secondary or incidental purpose.

About 23.3% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 247,000 acres in the 10 year and 312,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed Protection by Land Treatment (1000 Ac.)	Flood Plain Mgt. (1000 Ac.)	Structural Measures: Projects Multi-purpose Dams (No.)	Storage: Total (1000 Ac.Ft.)	Storage: Flood Prev.	Storage: Chan-nel Impr. (Mi.)	Cost: Structural Measures One Time ($ million)	Cost: Structural Measures Avg.Ann.* Total	Cost: Structural Measures Avg.Ann.* Flood Prev.	Benefits: Str.Measures % Damage Reduction	Benefits: Str.Measures Area Perm. Pool (1000 Ac.)
	1966			-								
NATIONAL EFFICIENCY												
	1980	-	1	-								
	2000	-	-	-								
	2020	-	-	-								
REGIONAL DEVELOPMENT												
	1980	-	1	-								
	2000	-	-	-								
	2020	38	-	1	1	9	3	-	.7	.1	.1	.1	1	.7
ENVIRONMENTAL QUALITY												
	1980	123	4	-								
	2000	246	122	-								
	2020	246	203	-								

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

UPSTREAM FLOOD DAMAGES, WATER MANAGEMENT
SUBREGION D

Subarea / Project Classification	General Watershed Data: Number of Projects	Total Water-shed Area sq.mi.	Pertinent Flood Plain Information: Area Inundated by 100 Year Freq. Flood: Crop & Pas-ture ac.	Wood-lands ac.	Other: Urban ac.	Other: Misc. ac.	Total ac.	Average Annual Flood Damage: Crop	Other: Agr.	Resid. & Indus:	Comm. & Trans.	Other	Total	Benefits: Flood Prev.: Agr. Damage: MIU & Redetn: CIU	Rec. Water: Mgt.:
								thousand dollars						thousand dolla	
AREA 14 RARITAN AND PASSA															
Not Evaluated	6	767													
Authorized P.L. 566	1	59	300	600	50	850	1800	-	-	-	-	-	44.8	44.8	25.9 - .6 41.8
Potential Flood Prev. Projects	8	708	3080	8295	645	18660	30580	12.0	7.4	467.8	268.2	103.9	3.5	862.8	137.6
Potential Developments	7	841	9305	8205	1430	9045	27985	41.8	20.1	65.8	12.8	26.4	1.8	168.7	81.7
TOTAL 4/	16	1608	12685	17100	2125	28455	60365	53.8	27.5	533.6	281.0	130.3	50.1	1076.3	245.2
AREA 15 DELAWARE RI															
15a	39	3563	9092	13364	962	37220	60638	65.7	38.2	213.6	109.2	160.4	74.2	661.3	349.6
15b	44	3373	8164	12129	1860	18590	40743	91.2	12.6	381.3	637.8	357.0	64.3	1544.2	1110.8
15c	10	1039	4145	1784	-	6229	12158	17.4	7.7	106.4	102.5	66.8	33.7	333.5	195.5
15d	44	4789	356864	167831	56208	188215	769118	1650.5	12.3	872.8	579.0	219.6	166.5	3500.7	2987.4
Not Evaluated	0														
Authorized P.L. 566	21	1336	11790	3023	1488	13222	29523	137.8	22.6	395.1	941.1	274.3	264.1	2035.0	1700.8 443.0 72.2 2400.9
Potential Flood Prev. Projects	26	2652	343103	152002	52181	119237	666523	1573.0	11.7	693.3	228.0	346.2	32.1	2884.3	2574.6
Potential Developments	90	8776	23372	40083	5361	117795	186611	114.0	36.5	485.7	259.4	182.3	42.5	1120.4	367.9
TOTAL 4/	137	12764	378265	195108	59030	250254	882057	1824.8	70.8	1574.1	1428.5	802.8	338.7	6039.7	4643.3
AREA 16 NEW JERSEY CO															
16a	4	347	310	845	50	8550	9755	2.1	.6	8.6	-	7.1	-	18.4	.4
16b	10	2047	5195	118650	2	195113	318960	19.1	8.2	5.0	-	20.8	1.0	54.1	8.9
Not Evaluated	0														
Authorized P.L. 566	0														
Potential Flood Prev. Projects	0														
Potential Developments	14	2394	5505	119495	52	203663	328715 6/	21.2	8.8	13.6	-	27.9	1.0	72.5	9.3
TOTAL 4/	14	2394	5505	119495	52	203663	328715 6/	21.2	8.8	13.6	-	27.9	1.0	72.5	9.3
SUBREGION D															
Not Evaluated	6	767													
Authorized P.L. 566	22	1395	12090	3623	1538	14072	31323	138	23	395	941	274	309	2080	1727 443 72 2443
Potential Flood Prev. Projects	34	3360	346183	160297	52826	137797	697103	1585	19	1161	496	450	96	3747	2712
Potential Developments	111	12011	38182	167783	6843	330503	543311	177	65	565	272	237	45	1361	459
TOTAL 4/	167	16766	396455	331703	61207	482372	1271737	1900	107	2121	1709	961	390	7188	4898

1/ To crest of emergency spillway.
2/ Storage for beneficial uses other than flood prevention.
3/ Includes redevelopment and/or redevelopment.
4/ Excludes Not Evaluated.
5/ Miles in miles.
6/ Area inundated exclusive of Barrier Islands.

Note: Inventory base 1966; Price base 1970; Ammortization rate, 5-1/8% over 100 years.

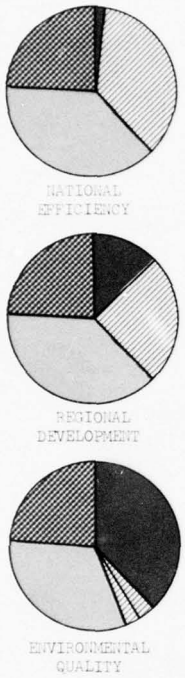
WATER MANAGEMENT AND STRUCTURAL MEASURES
SUBREGION D

Benefits and Costs														Upstream Structural Measures													
Benefits								Costs						No. of Dams	D.A. above Dams	Storage				Area Perm. Pool	Channel Imp.	Other Watershed Imp. 5/					
Flood Prev. Damage Redctn	Agr. Rec. MIU& CIU	Mgt.	Other Uses	Total	Flood Prev.	Agr. Water Mgt.	Rec.	Other Uses	Total Avrg. Annl.	Total Est. Cost						Sedi-ment	Flood-water	Other Uses 2/ Alloc.	Avail. 1/	Total							
thousand dollars					thousand dollars									sq.mi.	thousand acre feet					ac.	miles						
RARITAN AND PASSAIC RIVERS																											
						17.1					96.5	1637	1	7.2	.2	1.1	-	6.0	7.3	142							
44.8	44.8	25.9	-	.6	41.8	-	68.3	26.4	.6	39.2	-	66.2	1378	8	14.1	.5	.6	.2	-	1.3	139	3.0					
3.5	862.8	137.6						247.7				987.8	17067	20	116.6	3.3	19.1	.6	78.2	101.2	4367						
1.8	168.7	81.7						565.9				2347.2	40669	42	324.3	8.6	51.4	-	191.5	251.5	10703						
50.1	1076.3	345.2						840.0				3401.2	59114	70	455.0	12.4	71.1	.8	269.7	354.0	15209	3.0					
EA 15 DELAWARE RIVER																											
74.2	661.3	349.6						1987.9				5443.6	103707	100	796.9	18.8	141.9	.1	384.2	545.0	15395	-					
64.3	1544.2	1110.8						3161.9				8163.9	155138	177	993.0	22.5	166.3	8.5	347.4	544.7	22586	30.1					
33.7	333.5	195.5						478.2				1026.1	21071	37	123.4	2.8	22.4	.4	27.1	52.7	1866	-					
166.5	3900.7	2987.4						8305.9				5515.3	108127	114	860.5	21.6	145.2	50.6	228.8	446.2	26642	406.5	10.3				
264.1	2039.0	1700.8	443.0	72.2	2400.9	778.0	5619.3 3/	1421.8	58.8	836.1	590.1	2906.8	68725	78	358.8	5.4	66.7	47.5	-	119.6	3188	74.0	9.8				
32.1	2884.3	2574.6						1430.2				3345.1	59721	69	585.5	15.1	95.3	12.1	200.7	323.2	15465	380.4	.5				
42.5	1120.4	367.9						5081.9				13897.0	259597	281	1829.5	46.2	313.8	-	786.8	1145.8	47836	2.2					
338.7	6039.7	4643.3						7933.9				20148.9	388043	428	2773.8	65.7	475.8	59.6	987.5	1588.6	66480	456.6	10.3				
16 NEW JERSEY COASTAL																											
-	18.4	.4						35.1				72.0	1228	2	17.0	.5	2.7	-	3.0	6.2	252						
1.0	54.1	8.9						158.0				527.2	8936	18	187.0	5.0	30.0	-	84.4	119.4	10227						
1.0	72.5	9.3						193.1				599.2	10164	20	204.0	5.5	32.7	-	87.4	125.6	10479						
1.0	72.5	9.3						193.1				599.2	10164	20	204.0	5.5	32.7	-	87.4	125.6	10479						
SUBREGION D																											
						17					97	1637	1	7	-	1	-	6	7	142							
309	2080	1727	443	72	2443	778	5688	1448	59	875	590	2973	70103	86	373	6	67	48	-	121	3327	77	9.8				
36	3747	2712						1678				4333	76788	89	702	18	114	13	279	424	19832	380	.5				
45	1361	459						5841				16843	310430	343	2358	59	398	-	1066	1523	69018	2					
390	7188	4898						8967				24149	457321	518	3433	83	579	61	1345	2068	92177	459	10.3				

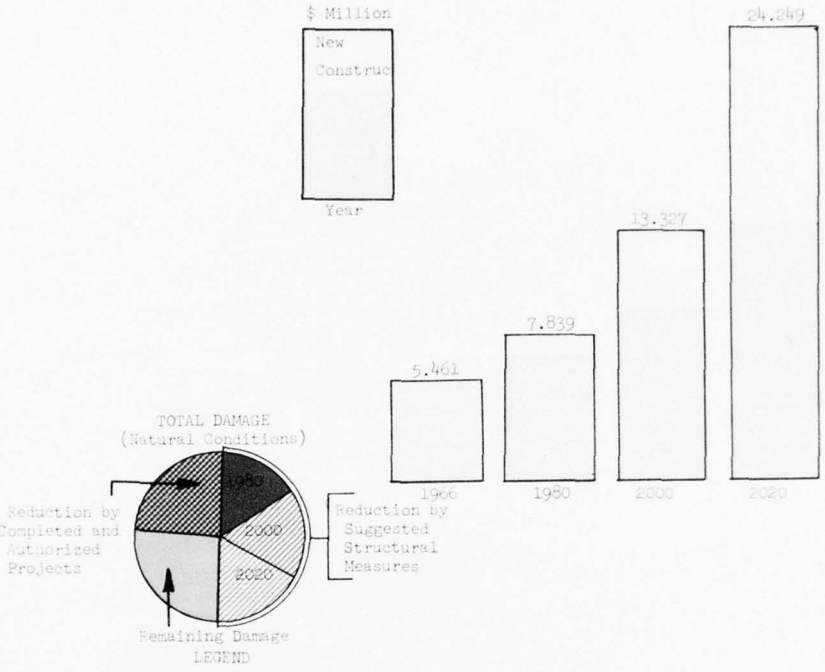
SUBREGION D
TABLE F-7

FLOOD DAMAGE DISTRIBUTION AND PROJECTIONS

DISTRIBUTION

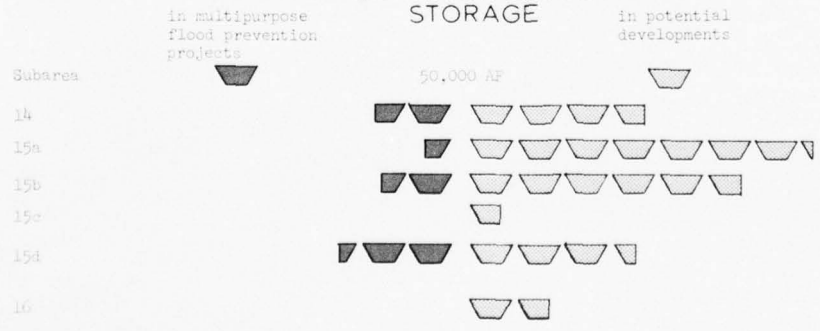


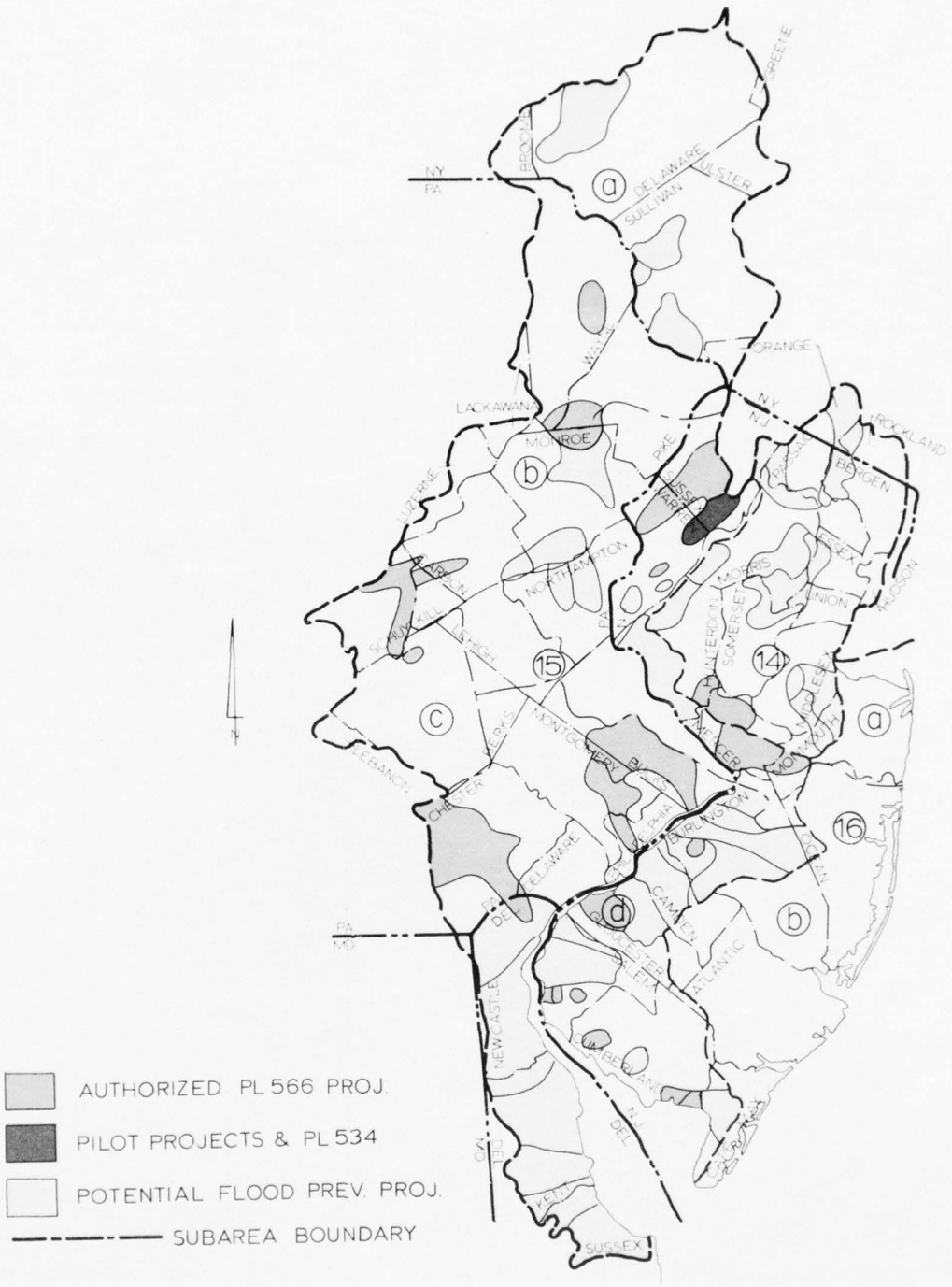
PRESENT AND PROJECTED AVERAGE ANNUAL DAMAGES



POTENTIAL WATER SUPPLY FROM UPSTREAM RESERVOIRS

BENEFICIAL USE STORAGE





SUB-REGION D

AREAS (14) - (16)

UPSTREAM FLOOD PREVENTION PROJECTS

10 0 10 20 30 40 Miles
SCALE

FIGURE F-22

USDA-SCS-HYATTSVILLE, MD. 1971

SUBREGION E (Areas 17 and 18)

Flooding

Area Inundated. Total area inundated by the 100 year frequency flood in the Subregion is approximately 2.72 million acres (Table F-8). Of this 44 percent is in crop and pasture, 39 percent is in forest land, and 17.0 percent is in urban and miscellaneous.

Area 18 has the largest area inundated (2.52 million acres) in the Region. Area 18 also has the largest acreage inundated in crop and pasture (1.10 million), forest land (0.99 million), and urban and miscellaneous (0.42) in the Region.

Area inundated as a percent of total area for the Subregion is 12. Area 18 has the largest percent of its land area inundated (54) in the Region. In contrast, Area 17 only has 1 percent of its area inundated.

Present Damages. The present average annual damage in the Subregion is approximately $15.4 million. The values for Areas 17 and 18 were $4.49 million and $10.9 million. For the Subregion, 64 percent is agricultural, and 36 percent is nonagricultural. The percent agricultural damage for Areas 17 and 18 were 8 and 87 respectively.

The present average annual damage in dollars per acre of area inundated for Areas 17 and 18 were $26 and $5 respectively. The average for the Subregion was $7.

There are 26 authorized PL 566 projects and one Pilot watershed in upstream areas which will reduce present average annual damage by $2.2 million, leaving a damage of $0.5 million. Present average annual damage in the remaining upstream areas is $14.9 million.

Future Damages. If no additional flood prevention measures were installed, the present average annual flood damages of $15.4 million would increase to $21.7 million in 1980, $33.4 million in 2000, and $55.8 million in 2020 (Figure F-23). The annual damages in 2020 for Areas 17 and 18 were $28.5 million and $27.3 million respectively.

Extent and Timing of Flood Prevention Measures

Structural Measures. Suggested flood prevention structural measures involving installation of 140 multiple purpose dams with 221,600 acre feet of flood prevention storage and 3,684 miles of channel improvement at an average annual cost of $4.80 million will reduce annual flood damage by $18.07 million in 2020. The tables on pages F-74 and F-75 indicate the extent and timing of potential flood prevention structural measures by Area.

AD-A036 627 CORPS OF ENGINEERS NEW YORK NORTH ATLANTIC DIV F/G 8/6
NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY. APPENDIX F. UPST--ETC(U)
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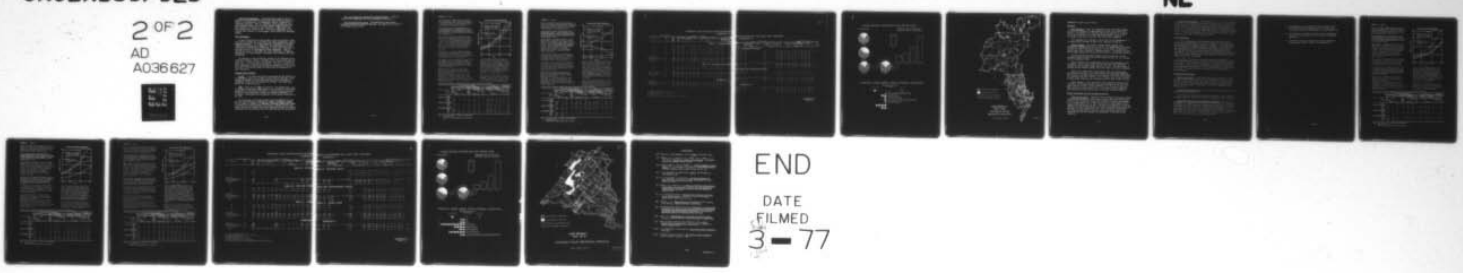


END

DATE
FILMED
3-77

Flood Plain Management. Flood prevention plans for the 2.7 million acre flood plain should include nonstructural measures or devices as alternatives, in combination, and/or in addition to structural measures. With all potential flood prevention structural measures installed, the annual damages remaining would be $6.6 million, $10.2 million, $17.0 million in 1980, 2000, and 2020 respectively (Figure F-23). Flood plain management of the 673,000 acres subject to high damages, would reduce this remaining damage.

Water Management

In the 23 authorized PL 566 projects there are included 15,200 acre feet of storage for uses other than flood prevention in multipurpose reservoirs. As of 1967 under the CO program of the USDA, technical assistance was provided for the installation of about 3,800 miles of diversions, 2,800 miles of tile, and 5,200 miles of open main ditches for drainage and flood prevention. Also installed were about 11,000 ponds for flood prevention, irrigation, recreation, fish and wildlife, livestock, rural domestic, and fire protection.

In addition to flood prevention storage in the Potential Flood Prevention Projects, there is storage of 0.47 million acre feet for other uses. There are about 1.52 million acre feet of storage for other uses in the Potential Developments. The total available for water management in potential upstream impoundments is 1.99 million acre feet. The specific needs for water will be identified in other appendices.

Programs and Activities

PL 566. As of 1967 there were 23 authorized PL 566 projects in the Subregion; seven are in Area 17, and 16 are in Area 18. Flood prevention storage of 33,100 acre feet and 15,200 acre feet of storage for other uses are included in 28 dams. The total estimated cost is $43.0 million.

RC&D. There are two RC&D's in Area 17. The primary objective of the Endless Mountains RC&D project is for a guide to the economic improvement of the family farm unit by increasing farm income and eliminating underemployment through the maximum development, improvement, conservation and utilization of the natural resources of the area.

The objectives of the South Central New York RC&D are to find uses for underdeveloped resources, to create a favorable climate for all types of industry, to maintain profitable family-type farms, to develop full-time employment and train or retrain citizens for careers within the Region, and to help landowners adjust to changing conditions and find economic uses for lands not used by agriculture.

Type II Coordinated Comprehensive Detailed Study. A Type II Study is near completion for the Susquehanna River Basin.

Type IV Cooperative Survey. The Appalachian Region Water Resources Survey was recently completed. The upper half of Area 17 is included in this study.

SUBREGION E - AREA 17

Floods of 100 year frequency magnitude inundate about 199,003 acres. Land use in this flood plain consists of 100,834 acres of cropland and pasture, 83,018 acres of forest, 650 acres of built-up, and 34,501 acres of miscellaneous lands.

Floods presently cause an estimated $4,489,700 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $6,914,100 in 1980; $13,603,800 in 2000; and $28,509,600 in 2020.

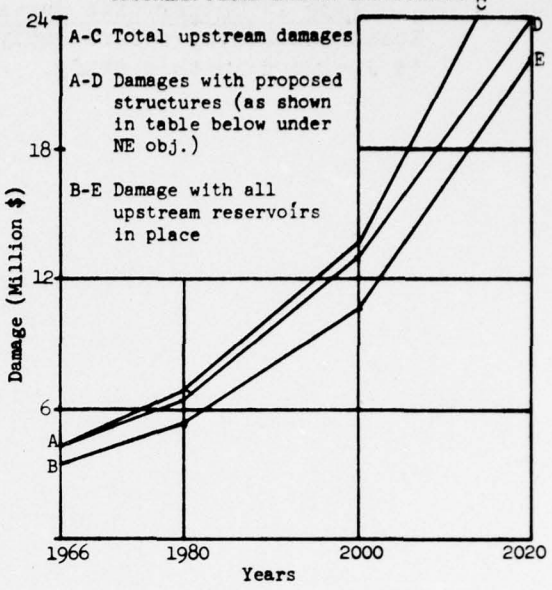
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 17,407,000 acres of land in Area 17, 6,330,000 acres require treatment and are feasible to treat. A net 2,863,000 acres will change use by 2020. Land use (1966) in the 145 watersheds consists of 4,019,000 acres of cropland, 1,474,000 acres of pasture, 9,779,000 acres of forest, 883,000 acres of urban, and 1,252,000 acres of other land.

Fully utilized, 521 potential upstream reservoir sites would have 2,230,000 acre feet of storage at an average cost of $386/acre foot. Allotment of the storage capacity is 23% for sediment and floodwater and 77% for other beneficial uses.

The release of 3,463 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 2,237 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
21,250 acres in 27 pools over 500 acres in size
30,150 acres in 100 pools 200-500 acres in size
24,460 acres in 179 pools 100-200 acres in size
13,700 acres in 206 pools less than 100 acres in size.
Average depths are 19 feet, 20 feet, 19 feet and 16 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 138 small watersheds in Area 17, 13 appear to warrant structural measures with flood prevention as a primary use. The 66 reservoirs with 66,200 acre feet of temporary storage could reduce flood damage by 15%. These 13 upstream watersheds deserve further study for early action projects. Another 397,100 acre feet of temporary storage in 475 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 1.1% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 113,000 acres in the 10-year and 169,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment	Flood Plain Mgt.	Structural Measures: Projects	Multi-purpose Dams	Storage: Total	Flood Prev.	Channel Impr.	Cost: Structural Measures: One Time Total	One Time Flood Prev.	Avg.Ann.* Total	Avg.Ann.* Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool
		1000 Ac.		No.	No.	1000 Ac.Ft.		Mi.	$ million					1000 Ac.
	1966			13	44	58	36	8						
NATIONAL EFFICIENCY														
	1980	84	-	3	9	35	17	-	12.6	6.3	.6	.3	3	1.0
	2000	69	1	3	9	42	6	-	6.9	1.7	.4	.1	3	1.1
	2020	332	1	7	48	224	51	-	108.7	27.2	5.6	1.4	10	7.6
REGIONAL DEVELOPMENT														
	1980	148	-	5	21	77	25	-	25.1	7.7	1.3	.4	4	2.7
	2000	112	1	4	15	61	8	-	18.1	1.8	1.0	.1	2	1.5
	2020	471	-	9	67	297	88	-	172.9	50.5	8.9	2.6	12	24.1
ENVIRONMENTAL QUALITY														
	1980	1266	51	13	66	280	74	-	128.3	36.9	6.6	1.9	16	9.7
	2000	2532	113	56	228	975	222	-	366.3	70.6	19.1	3.7	3	39.9
	2020	2532	35	56	227	975	222	-	366.2	70.5	19.1	3.7	3	39.9

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION E - AREA 18

Floods of 100 year frequency magnitude inundate about 2,518,800 acres. Land use in this flood plain consists of 1,102,923 acres of cropland and pasture, 990,030 acres of forest, 70,905 acres of built-up, and 354,942 acres of miscellaneous lands.

Floods presently cause an estimated $10,913,700 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $14,733,500 in 1980; $19,753,800 in 2000; and $27,384,300 in 2020.

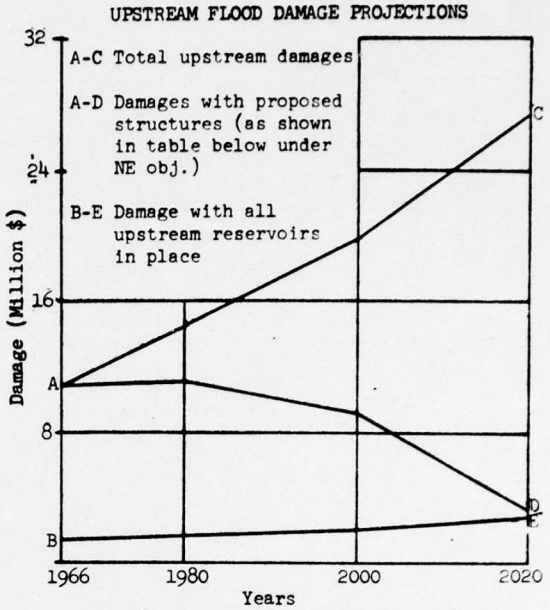
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 4,650,000 acres of land in Area 18, 2,467,000 acres require treatment and are feasible to treat. A net 1,372,000 acres will change use by 2020. Land use (1966) in the 116 watersheds consists of 1,766,000 acres of cropland, 209,000 acres of pasture, 1,740,000 acres of forest, 228,000 acres of urban, and 707,000 acres of other land.

Fully utilized, 76 potential upstream reservoir sites would have 420,200 acre feet of storage at an average cost of $251/acre foot. Allotment of the storage capacity is 36% for sediment and floodwater and 64% for other beneficial uses.

The release of 454 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 294 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
2,550 acres in 4 pools over 500 acres in size
5,160 acres in 18 pools 200-500 acres in size
4,310 acres in 29 pools 100-200 acres in size
1,050 acres in 14 pools less than 100 acres in size.
Average depths are 21 feet, 20 feet, 21 feet and 20 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 114 small watersheds in Area 18, 90 appear to warrant structural measures with flood prevention as a primary use. The 74 reservoirs with 116,600 acre feet of temporary storage could reduce flood damage by 89%. 3,684 miles of channel improvement are included in the 90 watersheds. These 90 upstream watersheds deserve further study for early action projects. Another 4,700 acre feet of temporary storage in 2 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 54.2% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 1,965,000 acres in the 10 year and 2,393,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment (1000 Ac.)	Flood: Plain: Mgt.	Structural Measures: Projects (No.)	Multi-purpose Dams (No.)	Storage: Total (1000 Ac.Ft.)	Storage: Flood Prev.	Storage: Channel Improv. (Mi.)	Cost: Structural Measures: One Time: Total ($ million)	One Time: Flood Prev.	Avg.Ann.*: Total	Avg.Ann.*: Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool (1000 Ac.)
	1966			16	4	17	9	1082						
NATIONAL EFFICIENCY														
	1980	985	80	22	21	119	44	810	25.1	12.6	1.4	.7	22	3.9
	2000	1389	-	31	31	167	61	1141	36.3	16.5	2.2	1.0	30	5.4
	2020	1102	19	37	22	129	43	1714	43.2	20.8	2.7	1.3	37	3.7
REGIONAL DEVELOPMENT														
	1980	1273	58	53	52	286	105	1951	61.3	28.9	3.6	1.7	52	9.3
	2000	1102	13	37	22	129	43	1714	43.2	20.8	2.7	1.3	37	3.7
	2020	-	28	-										
ENVIRONMENTAL QUALITY														
	1980	493	622	17	74	415	148	40	41.8	13.3	2.2	.7	8	13.0
	2000	987	1541	8	2	6	6	-	.8	.8	.1	.1	1	.1
	2020	987	355	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

UPSTREAM FLOOD DAMAGES, WATER MANAGEMEN
SUBREGION E

Subarea Project Classification	General Watershed Data: Number of Projects	Total Watershed Area sq.mi.	Area Inundated by 100 Year Freq. Flood: Crop & Pasture ac.	Wood-lands ac.	Other: Urban ac.	Other: Misc. ac.	Total ac.	Average Annual Flood Damage: Crop	Other: Agr.	Resid. & Indus:	Comm. & Trans.	Other	Total	Benefits: Flood Prev.: Damage Redctn	Agr.: Water: CLU	Rec Mgt.:
								thousand dollars						thousand do		
AREA 17 SUSQUEHANNA																
17a	31	7579	38239	8396	410	8122	55167	59.6	70.0	245.4	317.4	115.7	108.6	916.7	444.0	
17b	29	5832	9308	12687	-	7716	29711	7.9	10.1	313.9	304.6	596.0	42.4	1274.9	557.9	
17c	14	3252	11124	10015	-	5915	27054	9.2	23.0	261.9	143.8	88.8	15.9	542.6	94.1	
17d	45	7471	25316	20938	237	9288	55779	54.1	93.2	517.5	366.2	669.6	165.0	1865.6	391.0	
17e	19	3309	16847	10982	3	3460	31292	29.7	47.2	207.9	145.2	108.4	43.4	581.8	192.1	
Not Evaluated	1	68														
Authorized P.L. 566	13	875	4474	2106	450	1458	8488	78.8	4.1	178.6	272.5	110.0	147.8	791.8	691.9	218.1 37.1 458.
Potential Flood Prev. Projects	13	2084	9130	6427	57	4011	19625	11.7	38.0	317.1	444.4	539.6	65.3	1416.1	703.8	
Potential Developments	112	24484	87230	54485	143	29032	170890	70.0	201.4	1050.9	560.3	928.9	162.2	2973.7	283.4	
TOTAL 3/	138	27443	100834	63018	650	34501	199003	160.5	243.5	1546.6	1277.2	1578.5	375.3	5181.6	1679.1	
AREA 18 PATUXENT AND NANTI																
18a	17	2073	3310	4780	65	13880	22035	27.8	.3	31.6	42.0	88.0	438.7	628.4	545.0	
18b	97	5824	1099763	985275	70840	341087	2496965	10868.3	.4	114.1	82.8	519.9	241.0	11826.5	10768.8	
Not Evaluated	2	248														
Authorized P.L. 566	16	636	106830	140070	110	4944	251954	1845.2	-	.6	16.4	36.7	33.9	1932.8	1541.2	108.5 1480.3 366
Potential Flood Prev. Projects	90	6993	995738	849340	70795	345873	2261746	9047.1	.7	137.3	108.4	567.0	642.2	10502.7	9768.4	
Potential Developments	8	268	505	645	-	4150	5300	3.8	-	7.8	-	4.2	3.6	19.4	4.2	
TOTAL 3/	114	7897	1103073	990055	70905	354967	2519000	10896.1	.7	145.7	124.8	607.9	679.7	12454.9	11313.8	
SUBREGION E																
Not Evaluated	3	316														
Authorized P.L. 566	29	1511	111304	142176	560	6402	260442	1924	4	179	289	147	182	2725	2233	327 1517 82
Potential Flood Prev. Projects	103	9077	1004868	855767	70852	349884	2281371	9059	39	454	553	1107	708	11920	10472	
Potential Developments	120	24752	87735	55130	143	33182	176190	74	201	1059	560	933	166	2993	288	
TOTAL 3/	252	35340	1203907	1053073	71555	389468	2718003	11057	244	1692	1402	2187	1056	17638	12993	

1/ To crest of emergency spillway.
2/ Storage for beneficial uses other than flood prevention.
3/ Excludes Not Evaluated.
4/ Includes redevelopment and/or secondary benefits.
5/ Dikes in miles.

Note: Inventory base 1966; Price base 1970; Ammortization rate, 5-1/8% over 100 years.

WATER MANAGEMENT AND STRUCTURAL MEASURES
SUBREGION E

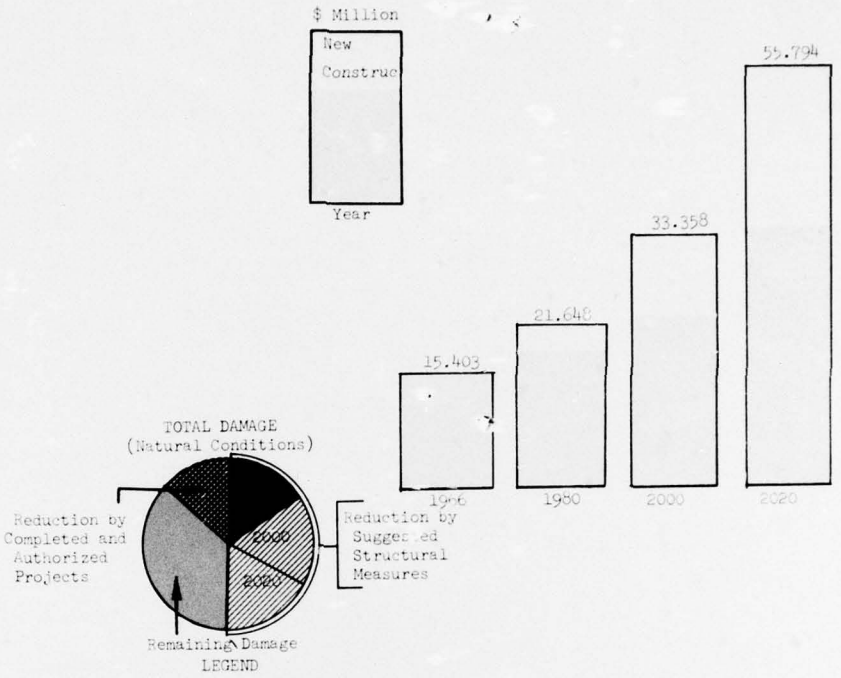
Damage			Benefits						Costs						No. of Dams	D.A. above	Upstream Structural Measures: Storage					Area	Channel	Other
Other	Total		Flood Prev. Damage Redctn	Agr.: MIU& Water: CLU Mgt.	Rec.	Other	Uses	Total	Flood Prev.	Agr. Water Mgt.	Rec.	Other	Uses	Total Avrg. Annl.	Total Est. Cost			Sedi-ment	Flood-water 1/	Other Uses 2/ Alloc.	Other Uses 2/ Avail.	Total	Perm. Pool	Imp.	Water-shed Imp. 3/
			thousand dollars						thousand dollars							sq.mi.	thousand acre feet					ac.	miles	
A 17 SUSQUEHANNA RIVER																								
108.6	916.7		444.0						2540.0					10313.6	197220	162	1301.1	13.1	127.2	2.4	398.0	540.7	23318	8.2	5.2
42.4	1274.9		557.9						2789.0					11839.7	229869	106	1133.6	9.0	104.9	15.5	275.1	404.5	12618		
15.9	542.6		94.1						829.2					6691.2	128599	67	687.9	9.9	43.1	-	281.6	334.6	13240		
165.0	1865.6		391.0						2538.3					11489.5	222416	173	1435.3	25.4	150.3	3.6	518.4	697.7	27721		
43.4	581.8		192.1						1090.5					5366.8	104299	57	567.4	12.8	59.1	-	238.2	310.1	13972		
147.8	791.8		691.9	218.1	37.1	458.1	21.8	1668.6 4/	578.7	2.9	272.9	16.6		871.1	21152	44	207.6	5.4	31.0	21.2	-	57.6	1322	8.2	5.2
65.3	1416.1		703.8						1894.8					6673.8	128747	66	722.9	8.1	66.2	-	205.7	280.0	9702		
162.2	2973.7		283.4						7313.5					38156.0	732504	455	4194.8	56.7	387.4	.3	1505.6	1950.0	79845		
375.3	5181.6		1679.1						9787.0					45700.9	882403	565	5125.3	70.2	484.6	21.5	1711.3	2287.6	90869	8.2	5.2
PATUXENT AND NANTICOKE RIVERS																								
438.7	628.4		545.0						552.0					1439.4	27908	46	431.8	21.2	81.3	5.7	174.4	282.6	7724	.3	
241.0	11826.5		10768.8						2988.4					6244.8	106968	34	339.6	11.6	48.9	1.8	92.7	155.0	6024	4765.3	
33.9	1932.8		1541.2	108.5	1480.3	366.8	250.6	4401.6 4/	593.3	575.4	8.9	90.7		1268.3	29053	4	121.8	.8	8.9	7.5	-	17.2	672	1081.7	
642.2	10502.7		9768.4						2908.5					6374.6	104628	74	624.2	30.7	116.6	-	266.9	414.2	13008	3683.9	
3.6	19.4		4.2						38.6					41.3	795	2	25.4	1.3	4.7	-	.2	6.2	68	-	
679.7	12454.9		11313.8						3540.4					7684.2	134476	80	771.4	32.8	130.2	7.5	267.1	437.6	13748	4765.6	
SUBREGION E																								
182	2725		2233	327	1517	825	272	6070 4/	1172	578	282	107		2139	50205	48	329	6	40	29	-	75	1994	1090	5
708	11920		10472						4803					13048	233375	140	1347	39	183	-	473	695	22710	3684	
166	2993		288						7352					38197	733299	457	4220	58	392	-	1506	1956	79913	-	
1056	17638		12993						13327					53384	1016879	645	5896	103	615	29	1979	2726	104617	4774	5

SUBREGION E
TABLE F-8

FLOOD DAMAGE DISTRIBUTION AND PROJECTIONS

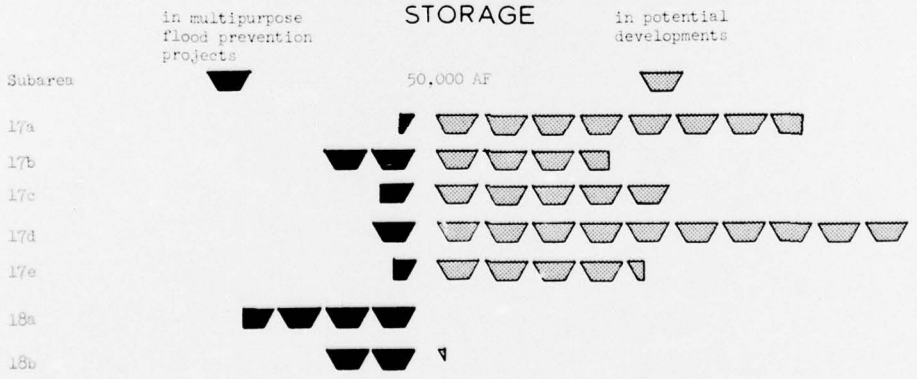
DISTRIBUTION

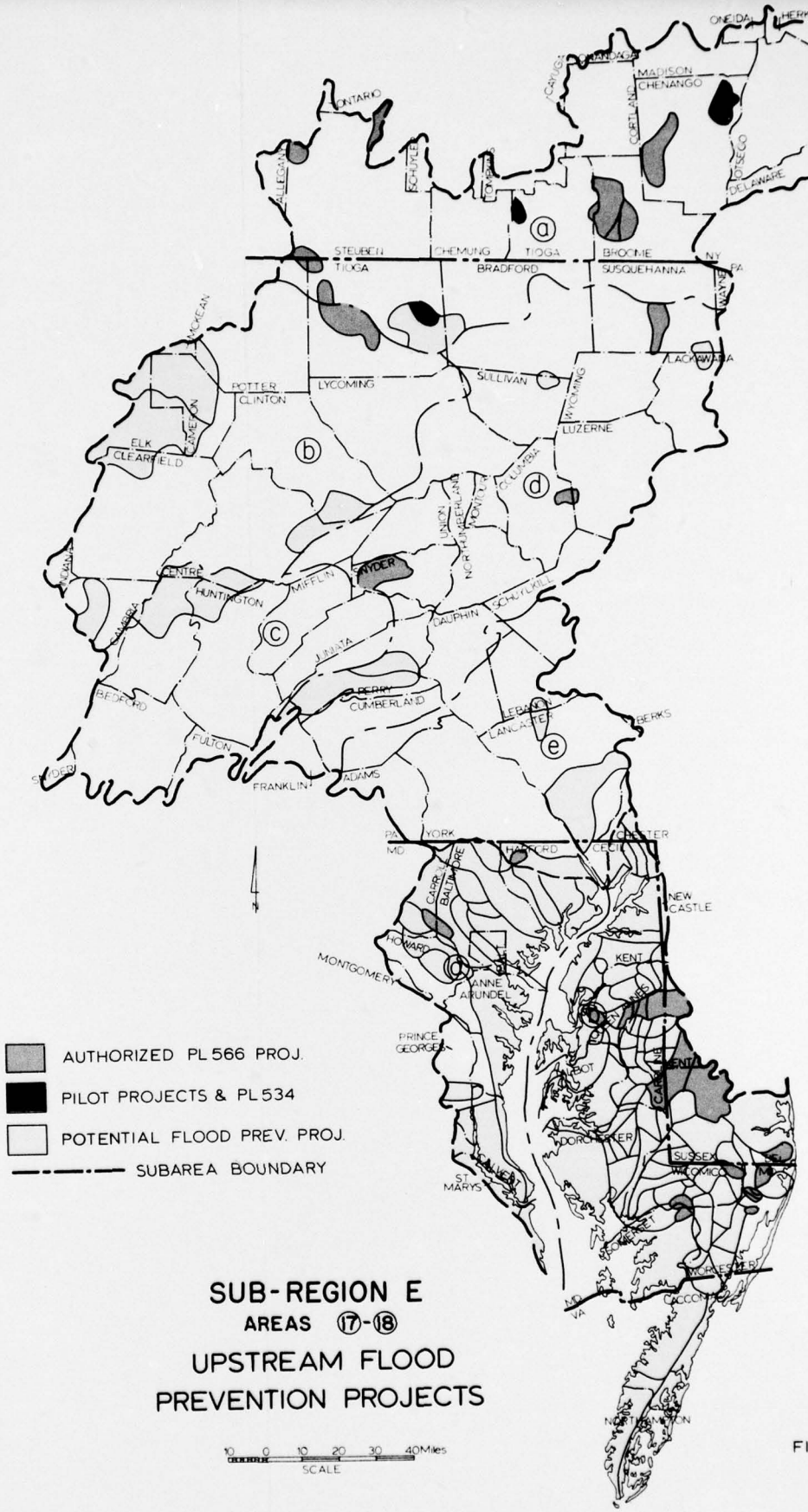
PRESENT AND PROJECTED AVERAGE ANNUAL DAMAGES



POTENTIAL WATER SUPPLY FROM UPSTREAM RESERVOIRS

BENEFICIAL USE STORAGE





SUB-REGION E

AREAS (17)-(18)

UPSTREAM FLOOD PREVENTION PROJECTS

FIGURE F-23

SUBREGION F (Areas 19, 20 and 21)

Flooding

Area Inundated. Total area inundated by the 100 year frequency flood in the Subregion is approximately 731,000 acres (Table F-9) Of this, 44 percent is in crop and pasture, 46 percent is in forest land, and 10 percent is in urban and miscellaneous. Area 19 has the greatest and Area 20 has the least total area inundated.

Area inundated as a percent of total area for the Subregion is 4. It ranged from 3 percent in Area 21 to 4 percent in Area 19.

Present Damages. The present average annual damage in the Subregion is approximately $10.1 million. It ranged from $1.0 million in Area 20 to $6.6 million in Area 19. Of the total, 36 percent is agricultural, and 64 percent is nonagricultural. The percent agricultural damage ranged from 30 percent in Area 21 to 49 percent in Area 20.

The present average annual damage in dollars per acre of area inundated ranged from $9. in Area 20 to $20. in Area 19. The average for the Subregion is $17.

Flash flooding in the mountainous portion of the Subregion occurs frequently. These storms create floods with very high velocities causing extreme property damage and loss of life. The same amount of rainfall in the flatter regions would not create as serious a problem.

There are 15 authorized PL 566 projects and 10 PL 534 projects in upstream areas which will reduce present average annual damage by $2.0 million, leaving a damage of $1.3 million. The 10 PL 534 projects are located in the upper reaches of the Potomac River Basin. Present average annual damage in the remaining upstream areas is $8.8 million.

Future Damages. If no additional flood prevention measures were installed, the present average annual flood damages of $10.1 million would increase to $16.2 million in 1980, $30.1 million in 2000, and $59.4 million in 2020 (Figure F-24). The range in annual damage in 2020 would be $4.6 million in Area 20 to $40.4 million in Area 19.

Extent and Timing of Flood Prevention Measures

Structural Measures. Suggested flood prevention structural measures involving installation of 515 multiple purpose dams with 820,500 acre feet of flood prevention storage and 162 miles of channel improvement at an average annual cost of $7.23 million will reduce annual flood damage by $20.66 million in 2020. The tables on pages F-81, 82 and 83 indicate the extent and timing of potential flood prevention structural measures for each objective by Area. The installation of measures involving National Forest land will depend upon their effects and compatibility with the multiple-use management of National Forest resources.

Flood Plain Management. Flood prevention plans for the 731,000 acre flood plain should include nonstructural measures or devices as alternatives, in combination, and/or in addition to structural measures. With all potential flood prevention structural measures installed, the annual damages remaining would be $9.5 million, $17.7 million, and $34.9 million in 1980, 2000 and 2020 respectively (Figure F-24). Flood plain management of the 172,000 acres subject to high damages, would reduce this remaining damage.

Water Management

In the 15 authorized PL 566 projects and 10 PL 534 projects there are included 13,000 acre feet of storage for uses other than flood prevention in multiple purpose reservoirs. As of 1967 under the CO program of the USDA, technical assistance was provided for the installation of about 700 miles of diversions, 2000 miles of tile and 3500 miles of open main ditches for drainage and flood prevention. Also installed were about 25,000 ponds for flood prevention, irrigation, recreation, fish and wildlife, livestock, rural domestic, and fire protection.

In addition to flood prevention storage in the Potential Flood Prevention Projects, there is storage of 1.22 million acre feet for other uses. There are about 1.46 million acre feet of storage for other uses in the Potential Developments. The total available for water management in potential upstream impoundments is 2.68 million acre feet. The specific needs for water will be identified in other appendices.

Programs and Activities

PL 566 and PL 534. As of 1967 there were 15 authorized PL 566 projects, and 10 PL 534 projects in the Subregion; 14 are in Area 19, five are in Area 20, and six are in Area 21. Flood prevention storage of 238,700 acre feet and 13,400 acre feet of storage for other uses are included in 224 dams. The total estimated cost is $50.9 million.

Type IV Cooperative Survey. The James River Basin Survey (Area 21) is nearing completion.

The Appalachian Region Water Resources Survey is near completion. The upper portions of Areas 19 and 21 are included in this survey.

Comprehensive Survey of the Potomac River Basin. The Corps of Engineers, in response to a Senate Public Works Committee resolution of January 26, 1956, initiated a comprehensive survey of the Potomac River Basin for the control of floods and the development and conservation of the basin's water and related land resources. The USDA began its activities in this survey in fiscal 1957 and completed them in fiscal year 1963. The USDA report was revised in 1965. The principal features of the revised plan were:

A. Installation of a system of upstream reservoirs with the modification and expansion of the original plan to provide additional developments for recreational use.

B. Acceleration and expansion of the current programs for land use and treatment to reduce erosion and sediment pollution.

C. Additional forestry programs which would contribute to making the Potomac a model of conservation.

F-1)

SUBREGION F - AREA 19

Floods of 100 year frequency magnitude inundate about 412,414 acres. Land use in this flood plain consists of 206,200 acres of cropland and pasture, 165,000 acres of forest, 82,000 acres of built-up, and 33,014 acres of miscellaneous lands.

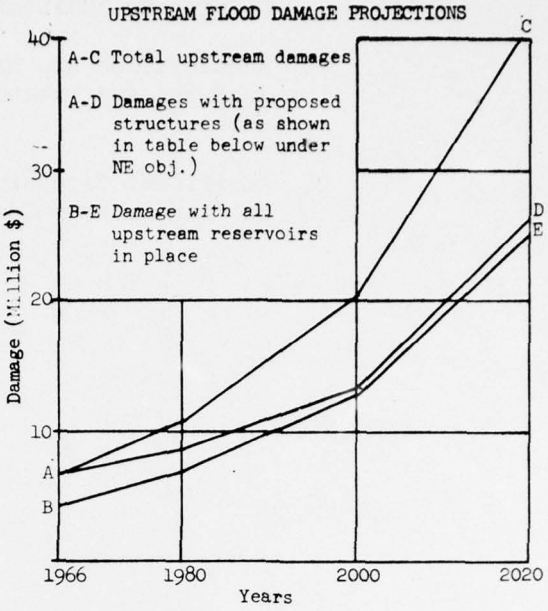
Floods presently cause an estimated $6,615,600 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $10,783,400 in 1980; $20,177,600 in 2000; and $40,355,200 in 2020.

Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 9,257,000 acres of land in Area 19, 4,521,000 acres require treatment and are feasible to treat. A net 1,267,000 acres will change use by 2020. Land use (1966) in the 79 watersheds consists of 1,823,000 acres of cropland, 1,148,000 acres of pasture, 5,289,000 acres of forest, 373,000 acres of urban, and 624,000 acres of other land.

Fully utilized, 407 potential upstream reservoir sites would have 1,213,400 acre feet of storage at an average cost of $255/acre foot. Allotment of the storage capacity is 36% for sediment and floodwater and 64% for other beneficial uses.

The release of 953 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 616 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
5,900 acres in 9 pools over 500 acres in size
11,480 acres in 35 pools 200-500 acres in size
13,740 acres in 95 pools 100-200 acres in size
10,400 acres in 174 pools less than 100 acres in size.
Average depths are 11 feet, 20 feet, 16 feet and 18 feet respectively.



Of the 79 small watersheds in Area 19, 35 appear to warrant structural measures with flood prevention as a primary use. The 315 reservoirs with 350,900 acre feet of temporary storage could reduce flood damage by 34%. These 35 upstream watersheds deserve further study for early action projects. Another 10,500 acre feet of temporary storage in 92 reservoirs could possibly be developed *in projects with flood prevention as a* secondary or incidental purpose.

About 4.5% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 252,000 acres in the 10 year and 363,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment 1000 Ac.	Flood Plain Mgt.	Structural Measures: Projects No.	Multi-purpose Dams No.	Storage: Total 1000 Ac.Ft.	Storage: Flood Prev.	Channel Improv. Mi.	Cost: Structural Measures: One Time Total $ million	One Time Flood Prev.	Avg.Ann.* Total	Avg.Ann.* Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool 1000 Ac.
	1966			14	142	152	146	49						
NATIONAL EFFICIENCY														
	1980	1491	11	16	158	500	211	-	121.3	28.6	7.2	1.7	17	15.2
	2000	243	5	19	157	478	203	-	114.3	34.9	7.2	2.2	18	16.0
	2020	-	32	-										
REGIONAL DEVELOPMENT														
	1980	2491	9	29	263	835	352	-	200.8	57.6	11.5	3.3	30	26.2
	2000	183	7	6	52	143	62	-	34.8	7.2	2.9	.6	4	5.0
	2020	-	16	-										
ENVIRONMENTAL QUALITY														
	1980	904	97	35	315	978	414	-	235.7	63.8	14.4	3.9	34	31.2
	2000	1808	253	30	92	235	23	-	73.9	-	4.3	-	1	10.4
	2020	1808	62	-										

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

SUBREGION F - AREA 20

Floods of 100 year frequency magnitude inundate about 131,470 acres. Land use in this flood plain consists of 45,013 acres of cropland and pasture, 68,541 acres of forest, 703 acres of built-up, and 17,213 acres of miscellaneous lands.

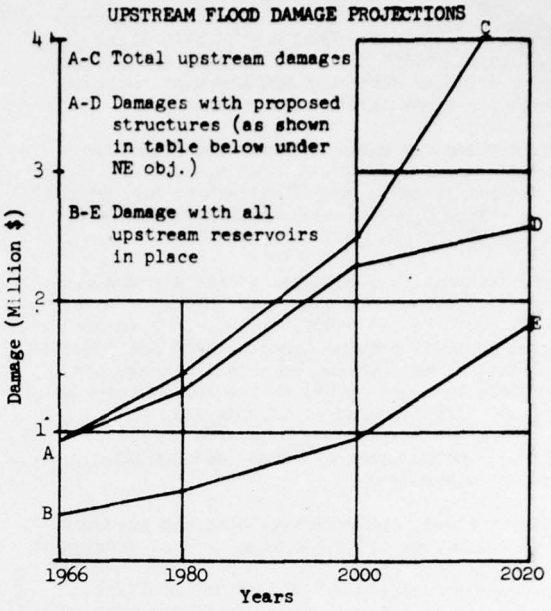
Floods presently cause an estimated $950,400 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $1,435,100 in 1980; $2,499,500 in 2000; and $4,628,400 in 2020.

Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 3,736,000 acres of land in Area 20, 1,638,000 acres require treatment and are feasible to treat. A net 552,000 acres will change use by 2020. Land use (1966) in the 32 watersheds consists of 582,000 acres of cropland, 359,000 acres of pasture, 2,441,000 acres of forest, 116,000 acres of urban, and 238,000 acres of other land.

Fully utilized, 217 potential upstream reservoir sites would have 1,068,600 acre feet of storage at an average cost of $132/acre foot. Allotment of the storage capacity is 33% for sediment and floodwater and 67% for other beneficial uses.

The release of 901 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 583 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
11,640 acres in 18 pools over 500 acres in size
27,960 acres in 87 pools 200-500 acres in size
11,140 acres in 79 pools 100-200 acres in size
2,820 acres in 42 pools less than 100 acres in size.
Average depths are 13 feet, 15 feet, 16 feet and 19 feet respectively.



Of the 27 small watersheds in Area 20, 9 appear to warrant structural measures with flood prevention as a primary use. The 109 reservoirs with 143,700 acre feet of temporary storage could reduce flood damage by 44%. These 9 upstream watersheds deserve further study for early action projects. Another 163,800 acre feet of temporary storage in 108 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 3.5% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 99,000 acres in the 10 year and 125,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed: Protection by Land Treatment	Flood Plain Mgt.	Structural Measures: Projects	Multi-purpose Dams	Storage: Total	Flood Prev.	Channel Impr.	Cost: Structural Measures: One Time: Total	One Time: Flood Prev.	Avg.Ann.* : Total	Avg.Ann.* : Flood Prev.	Benefits: Str.Measures: % Damage Reduction	Area Perm. Pool
		1000 Ac.		No.	No.	1000 Ac.Ft.		Mi.	$ million					1000 Ac.
	1966			5	48	50	45	148						
NATIONAL EFFICIENCY														
	1980	12	1	1	18	108	37	-	27.9	8.0	1.4	.4	8	3.3
	2000	-	1	-										
	2020	453	-	8	91	358	130	90	55.8	13.5	2.9	.7	36	18.4
REGIONAL DEVELOPMENT														
	1980	12	1	1	18	108	37	-	27.9	8.0	1.4	.4	8	3.3
	2000	271	-	6	49	218	71	74	36.2	11.4	1.9	.6	16	8.7
	2020	182	1	2	42	140	59	16	19.5	2.0	1.0	.1	20	9.7
ENVIRONMENTAL QUALITY														
	1980	328	24	9	109	466	167	90	83.7	21.4	4.3	1.1	44	21.7
	2000	655	90	7	58	324	102	171	59.9	12.7	3.3	.7	9	15.6
	2020	655	17	6	50	278	87	146	51.6	13.4	2.7	.7	8	13.4

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

Floods of 100 year frequency magnitude inundate about 187,690 acres. Land use in this flood plain consists of 95,065 acres of cropland and pasture, 79,540 acres of forest, 2,900 acres of built-up, and 10,185 acres of miscellaneous lands.

Floods presently cause an estimated $2,540,500 average annual damage. Without meeting any flood prevention demands, projected damages are expected to be: $3,988,600 in 1980; $7,393,900 in 2000; and $14,379,200 in 2020.

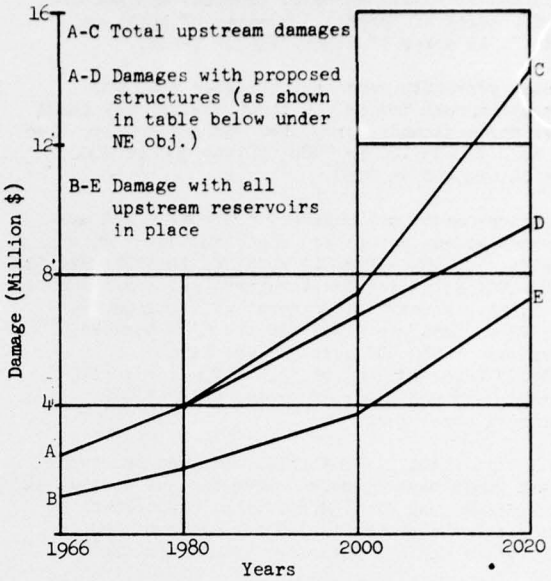
Land treatment, use changes, protection and management affect volume and distribution of water yields. Of the 6,639,000 acres of land in Area 21, 3,444,000 acres require treatment and are feasible to treat. A net 606,000 acres will change use by 2020. Land use (1966) in the 100 watersheds consists of 636,000 acres of cropland, 532,000 acres of pasture, 4,916,000 acres of forest, 346,000 acres of urban, and 209,000 acres of other land.

Fully utilized, 196 potential upstream reservoir sites would have 1,896,800 acre feet of storage at an average cost of $120/acre foot. Allotment of the storage capacity is 38% for sediment and floodwater and 62% for other beneficial uses.

The release of 1,775 cfs (based on continual draft) could augment flows for water quality control, recreation, navigation or downstream withdrawals. Or the potential upstream reservoirs could supply 1,147 mgd for power, rural communities and towns, industry and irrigation.

Water surfaces of various sizes may satisfy recreation, fish and wildlife, and/or visual quality environment needs. Potential upstream reservoirs could provide:
40,200 acres in 44 pools over 500 acres in size
24,000 acres in 76 pools 200-500 acres in size
10,100 acres in 69 pools 100-200 acres in size
3,700 acres in 64 pools less than 100 acres in size.
Average depths are 18 feet, 19 feet, 23 feet and 27 feet respectively.

UPSTREAM FLOOD DAMAGE PROJECTIONS



Of the 73 small watersheds in Area 21, 27 appear to warrant structural measures with flood prevention as a primary use. The 91 reservoirs with 204,500 acre feet of temporary storage could reduce flood damage by 36%. 74 miles of channel improvement are included in the 27 watersheds. These 27 upstream watersheds deserve further study for early action projects. Another 392,500 acre feet of temporary storage in 105 reservoirs could possibly be developed in projects with flood prevention as a secondary or incidental purpose.

About 2.8% of the land area is in the 100 year flood plain. Early action flood plain management is needed on the 143,000 acres in the 10 year and 178,000 acres in the 50 year flood plains in upstream watersheds.

Suggested flood prevention demands shown below are those used in plan formulation.

Objective	Time Frame Year	Flood Prevention Demands: Watershed Protection by Land Treatment 1000 Ac.	Flood Plain Mgt. 1000 Ac.	Structural Measures: Projects No.	Multi-purpose Dams No.	Storage: Total 1000 Ac.Ft.	Storage: Flood Prev.	Storage: Channel Impr. Mi.	Cost: Structural Measures One Time Total $ million	Cost: Structural Measures One Time Flood Prev. $ million	Cost: Structural Measures Avg.Ann.* Total $ million	Cost: Structural Measures Avg.Ann.* Flood Prev. $ million	Benefits: Str.Measures % Damage Reduction	Benefits: Str.Measures Area Perm. Pool 1000 Ac.
	1966			6	34	50	48	74						
NATIONAL EFFICIENCY														
	1980	69	4	3	10	51	19	23	5.6	1.9	.3	.1	1	1.7
	2000	195	4	8	20	138	52	17	18.1	8.0	.9	.4	9	3.4
	2020	495	3	16	61	404	169	32	62.7	25.8	3.4	1.4	24	10.8
REGIONAL DEVELOPMENT														
	1980	199	4	6	28	153	58	23	20.9	7.0	1.2	.4	6	4.4
	2000	469	3	17	50	352	144	49	44.6	23.3	2.3	1.2	22	8.8
	2020	102	3	10	29	284	50	57	41.8	16.4	2.3	.9	11	9.6
ENVIRONMENTAL QUALITY														
	1980	689	51	27	91	593	240	72	86.4	37.6	4.6	2.0	34	15.9
	2000	1378	127	20	53	654	238	157	71.1	30.7	3.7	1.6	8	23.0
	2020	1378	10	20	52	653	238	156	69.7	26.4	3.7	1.4	8	22.9

NOTE: The values shown in the table are incremental.
Price Base 1970
* Amortized at 5-1/8% interest over 100 years.

UPSTREAM FLOOD DAMAGES, WATER MANAG
SUBREGION

Subarea Project Classification	General Watershed Data: Number of Projects	Total Watershed Area sq.mi.	Pertinent Flood Plain Information: Area Inundated by 100 Year Freq. Flood: Crop & Pasture ac.	Wood-lands ac.	Other: Urban ac.	Other: Misc. ac.	Total ac.	Average Annual Flood Damage: Crop	Other: Agr.	Resid. & Indus:	Comm.	Trans.	Other	Total	Flood Prev. Damage: MIU Redctn: CLU
										thousand dollars					
AREA 19 POTOM															
19a	24	4202													
19b	14	3028													
19c	41	7440													
Not Evaluated	0														
Authorized P.L. 566 & 534	14	2256					39994	476.4	410.4	546.1	263.8	612.9	562.8	2872.4	1650.5 205.
Potential Flood Prev. Projects	35	8559					256770							4494.8	2265.4
Potential Developments	30	3855					115650							898.9	26.9
TOTAL 5/	79	14670	206200	165000	8200	33014	412414	1405.0	1157.0	1571.0	759.0	1736.0	1638.1	8266.1	3942.8
AREA 20 YORK AND RAPP															
20a	13	2581	26451	13965	663	5448	46527	237.3	73.8	107.2	11.8	158.4	21.3	609.8	403.7
20b	14	2827	18562	54576	40	11765	84943	213.0	34.5	11.9	8.3	193.7	60.1	521.5	355.0
Not Evaluated	5	595													
Authorized P.L. 566	5	498	1397	3277	138	68	4880	126.2	8.2	17.2	-	25.9	37.5	215.0	180.9 86.
Potential Flood Prev. Projects	9	1961	25474	22986	565	6573	55598	208.1	71.1	97.6	13.1	197.9	35.8	623.6	415.2 439.
Potential Developments	13	2949	18142	42278	-	10572	70992	116.0	29.0	4.3	7.0	128.3	8.1	292.7	162.6 392.
TOTAL 5/	27	5408	45013	68541	703	17213	131470	450.3	108.3	119.1	20.1	352.1	81.4	1131.3	758.7 918.
AREA 21 JAME															
21a	34	3760	64160	13975	1770	6345	86250	271.0	106.8	1134.4	399.0	91.5	2002.7	1072.8	
21b	37	3229	30565	64405	1130	3825	99925	346.5	52.4	50.1	219.7	68.3	737.0	424.8	
21c	2	214	340	1160	-	15	1515	4.0	2.1	1.4	.7	1.6	9.8	3.4	
Not Evaluated	27	3397					74615						332.7	42.0	
Authorized P.L. 566	6	672	7370	10495	280	1315	19460	167.1	2.2	-	20.6	73.4	263.3	209.0 49.	
Potential Flood Prev. Projects	27	2317	51650	14550	1155	5060	72415	242.1	69.0	835.6	336.2	58.0	1540.9	872.4	
Potential Developments	40	4214	36045	54495	1465	3810	95815	212.3	90.1	350.3	262.6	30.0	945.3	419.6	
TOTAL 5/	73	7203	95065	79540	2900	10185	187690	621.5	161.3	1185.9	619.4	161.4	2749.5	1501.0	
SUBREGION															
Not Evaluated	32	3992					74615						333	42	
Authorized P.L. 566 & 534	25	3426					64334	770	421	827	659	674	3351	2040	341
Potential Flood Prev. Projects	71	12837					384783						6659	3553	
Potential Developments	83	11018					282457						2137	609	
TOTAL 5/	179	27281	346278	313081	11803	60412	731574	2477	1427	3655	2708	1881	12147	6202	

1/ To crest of emergency spillway.
2/ Storage for beneficial uses other than flood prevention.
3/ Floodwater diversion in miles
4/ Number of grade stabilization structures.
5/ Excludes Not Evaluated.
6/ Includes redevelopment and/or secondary benefits.

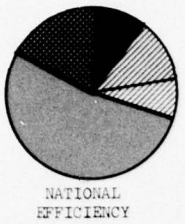
Note: Inventory base 1966; Price base 1970; Ammortization rate, 5-1/8% over 100 years.

S, WATER MANAGEMENT AND STRUCTURAL MEASURES
SUBREGION F

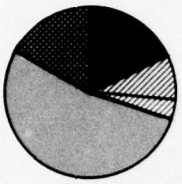
Damage			Benefits						Costs					Upstream Structural Measures								
	Other:	Total	Flood Prev.: Damage: Redctn:	Agr.: MIU&: CLU	Rec.: Water: Mgt.:	Other: Uses	Total		Flood: Prev.: Mgt.	Agr.: Water:	Rec.:	Other: Uses	Total: Avrg.: Annl.:	Total Est. Cost	No. of Dams	D.A. above Dams	Storage: Sedi-ment	Flood-water 1/	Other Uses 2/: Alloc.	Total: Avail.	Area: Perm. Pool	Channel: Imp.	Other Beneficial Imp.
			thousand dollars						thousand dollars							sq.mi.	thousand acre feet				ac.	miles	
AREA 19 POTOMAC RIVER																							
									2164.4	-	2541.6	194.4	4900.4	93874	172	1002.2	24.9	182.2	102.1	-	309.2	5812	1.4 3/
									1121.3	-	2364.8	363.2	3849.3	71802	138	1330.3	21.1	107.3	118.0	-	246.4	6685	26.1 3/ 4/
									2030.8	-	5228.1	3271.0	10529.9	183061	239	1723.1	44.2	203.1	562.4	-	809.7	3140	21.4
9	562.8	2872.4	1650.5	205.0	-	293.3	173.6	2414.8 6/	1441.2	-	138.0	32.4	1611.6	39269	142	1100.2	14.4	131.2	6.3	-	151.9	2242	48.6 1.2 3/ 4/
		4494.8	2265.4						3875.3	-	7306.7	2967.8	13879.8	235808	315	2423.9	63.2	350.9	563.8	-	977.9	31162	.3
		898.9	26.9						-	-	2689.8	1098.4	3788.2	73660	92	531.5	12.6	10.5	212.4	-	235.5	10313	
0	1638.1	8266.1	3942.8						5316.5	-	10134.5	3828.6	19279.6	348737	549	4055.6	90.2	492.6	782.5	-	1365.3	43757	48.9 3/ 4/
YORK AND RAPPAHANNOCK RIVERS																							
4	21.3	609.8	403.7						1565.6				4589.8	88287	124	776.2	25.6	162.7	2.0	396.5	586.8	23002	83.9
7	60.1	521.5	355.0						1344.3				3187.2	59429	141	911.0	32.2	179.5	6.3	313.8	531.8	29871	456.6
9	37.5	215.0	180.9	86.4	20.4	41.3	13.8	386.8 6/	57.9	23.5	7.6	19.0	129.7	2270	8	47.7	1.6	10.2	-	20.5	32.3	1913	
9	35.8	623.6	415.2	439.7					202.6				252.7	6358	48	209.0	10.0	34.7	5.3	-	50.0	1241	148.6
3	8.1	292.7	162.6	392.7					1269.5				4427.1	84392	109	679.2	23.0	143.7	3.0	296.9	466.6	21524	89.2
									1437.8				30972	56966	108	799.0	24.8	163.8	-	413.4	602.0	30108	303.3
1	81.4	1131.3	758.7	918.8					2909.9				7777.0	147716	265	1687.2	57.8	342.2	8.3	710.3	1118.6	52873	540.5
AREA 21 JAMES RIVER																							
0	91.5	2002.7	1072.8						3331.0				7029.9	133813	117	1450.0	50.4	325.6	36.2	504.5	916.7	21563	113.3
7	68.3	737.0	424.8						1918.8				5029.9	98130	112	1469.8	71.8	312.3	7.5	637.6	1029.2	41650	352.2
7	1.6	9.8	3.4						7.2				8.4	145	1	3.5	.2	.9	-	-	1.1	27	1.4
		332.7	42.0						676.1				1999.6	42306	69	496.0	20.8	109.1	-	261.4	391.3	15939	
6	73.4	263.3	209.0	49.8	-	-	7.8	301.4 6/	207.9	-	-	4.9	212.8	5238	34	241.7	6.6	41.8	1.8	-	50.2	891	73.5
2	58.0	1540.9	872.4						2084.0				4559.3	85817	91	924.5	35.2	204.5	16.6	336.7	593.0	16609	72.7
6	30.0	945.3	419.6						2965.1				7296.1	141033	105	1757.1	80.6	392.5	25.3	805.4	1303.8	45740	320.7
4	161.4	2749.5	1501.0						5257.0				12068.2	232088	230	2923.3	122.4	638.8	43.7	1142.1	1947.0	63240	466.9
SUBREGION F																							
		333	42						734				2129	44576	77	544	22	119	-	282	423	18662	
	674	3351	2040	341	20	335	195	3103 6/	1852	24	146	56	2077	50865	224	1551	31	208	13	-	252	4374	270 1.2 3/ 4/
		6659	3553						7229				22866	406017	515	4028	121	699	583	634	2037	69295	168
		2137	609						4403				14182	271659	305	3088	118	567	238	1219	2142	86201	694
	1881	12147	6202						13484				39125	728541	1044	8667	270	1474	834	1853	4431	159870	1056 1.2 3/ 4/

FLOOD DAMAGE DISTRIBUTION AND PROJECTIONS

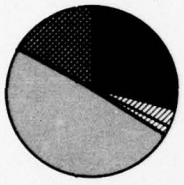
DISTRIBUTION



NATIONAL EFFICIENCY

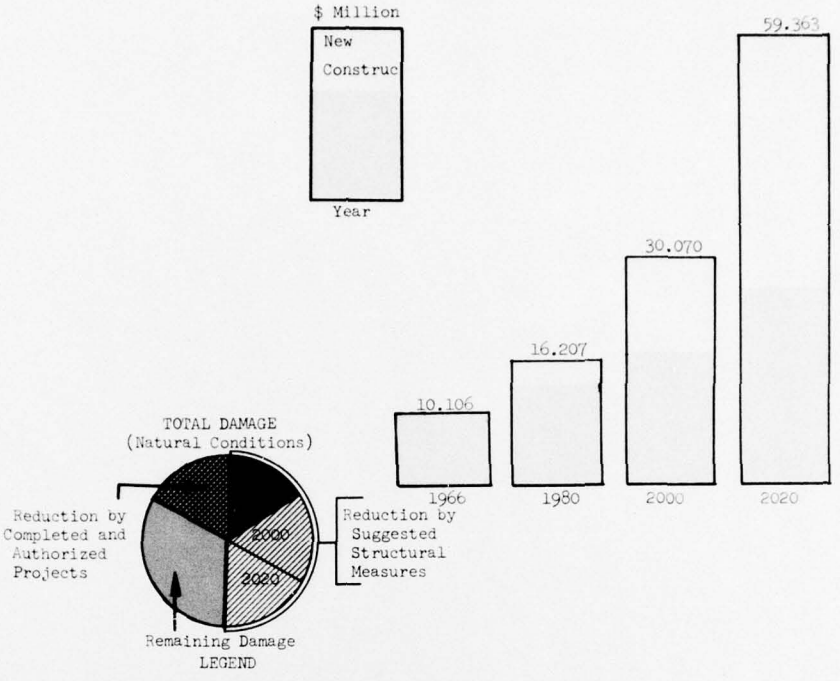


REGIONAL DEVELOPMENT

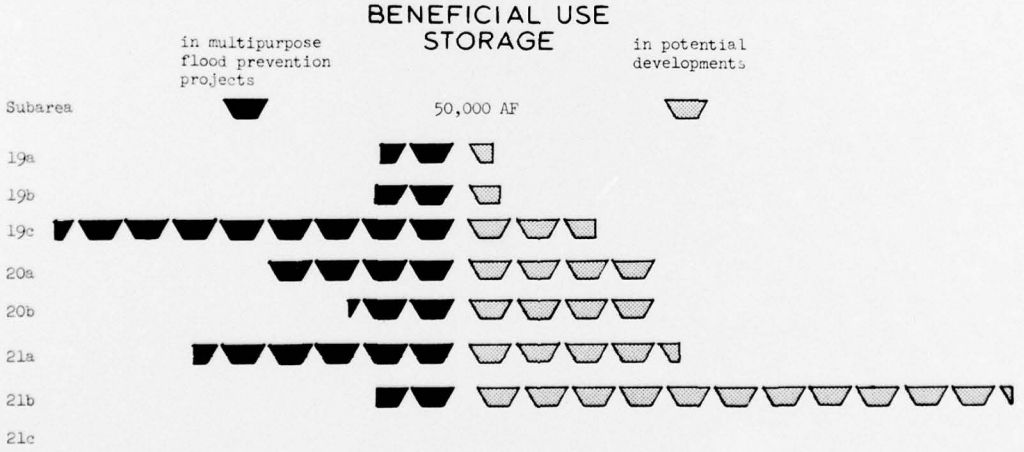


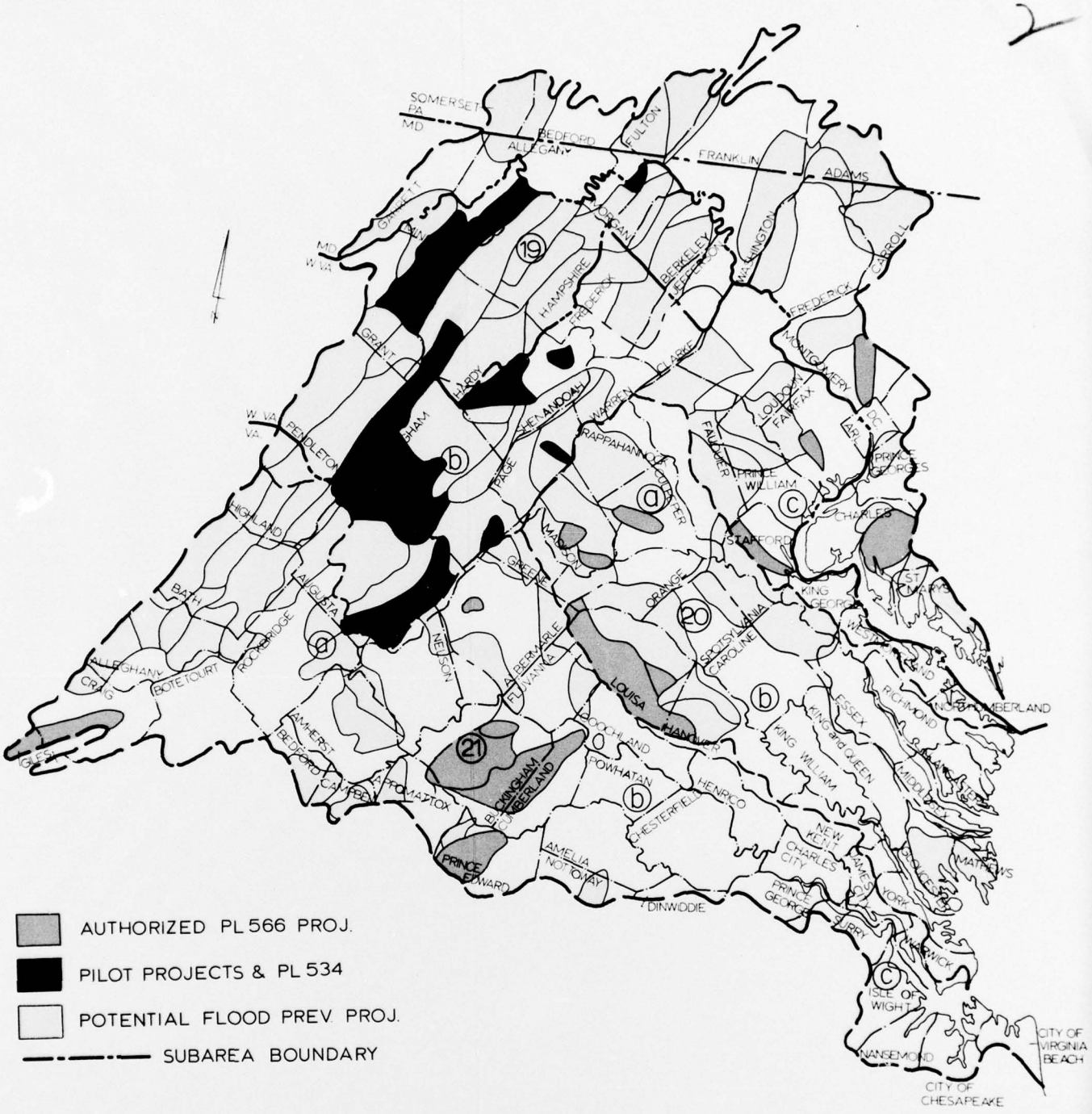
ENVIRONMENTAL QUALITY

PRESENT AND PROJECTED AVERAGE ANNUAL DAMAGES



POTENTIAL WATER SUPPLY FROM UPSTREAM RESERVOIRS





SUB-REGION F

AREAS (19) - (21)

UPSTREAM FLOOD PREVENTION PROJECTS

10 0 10 20 30 40 Miles

SCALE

FIGURE F-24

USDA-SCS-HYATTSVILLE, MD 1971

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USDA-SCS-FAYETTEVILLE, NO. (07)